The BP Solar

advantage

Premium Performance Crystalline

Laser Grooved Monocrystalline

- World leading efficiency—ideal for maximizing power and reducing installation cost
- Market leading energy generating kWh/kWp performance demonstrated in third party tests
- Leading commercial laser cell processing provides a power boost over other technologies
- Superior power tolerance
- Standard 25 year power warranty and 5 year materials and workmanship warranty.

Performance Crystalline

Enhanced Monocrystalline and Multicrystalline

- High power performance achieved through enhanced cell processing technology
- High efficiency and reliability for diverse grid and off-grid applications
- Widest selection of module sizes from 5 to 160 W
- Specialized frame and voltage options for small modules
- Standard 20 or 25 year power warranty.*

High Performance Crystalline

Premium Enhanced Multicrystalline

- Superior energy generating kWh/kWp performance
- Excellent efficiency and reliability through enhanced cell processing technology
- Superior power tolerance
- Attractive dark frame appearance
- Standard 25 year power warranty and 5 year materials and workmanship warranty.

High Performance Thin Film

Advanced Millennia™ & Apollo®
Thin Film Technology

- Most cost-effective power output where space is not a constraint
- Market leading thin film efficiencies
- Superior energy generating kWh/kWp performances
- Aesthetic appearance: glass over uniform black substrate easily fits into a building's design
- Standard 20 year power warranty for Millennia™ and 10 year power warranty for Apollo®.

www.bpsolar.com

* Modules 50w and below have power warranties of 20 years or less.

USA

Alternative Solar Products - California
Toll Free: 800.229.7652
Phone: 909.308.2366
E-mail: mark@alternativesolar.com
Internet: www.alternativesolar.com

Atlantic Solar Products, Inc. - Maryland
Toll Free: 800.807.2857
Phone: 410.686.2500
E-mail: mail@atlanticsolar.com
Internet: www.atlanticsolar.com

Dankoff Solar Products - New Mexico
Toll Free: 888.396.6611
Phone: 505.473.3800
E-mail: pumps@dankoffsolar.com
Internet: www.dankoffsolar.com

Effective Solar Products - Louisiana
Toll Free: 888.824.0090
Phone: 504.537.0090
E-mail: esp@effectivesolar.com
Internet: www.effectivesolar.com

Hutton Communications - Georgia
Toll Free: 877.896.2806
Phone: 770.963.1380
Fax: 770.963.9335
E-mail: sales@huttonsolar.com
Internet: www.huttonsolar.com

Intermountain Solar Technologies - Utah
Toll Free: 800.671.0169
Phone: 801.501.9353
E-mail: orrin@intermountainsolar.com
Internet: www.intermountainwholesale.com

Polar Wire - Alaska
Phone: 907.561.5955
Fax: 907.561.4233
E-mail: sales@polarwire.com
Internet: www.polarwire.com

Schott Applied Power Corp. - California
Toll Free: 800.777.7075
Phone: 707.923.2277
E-mail: sales@appliedpower.com
Internet: www.appliedpower.com

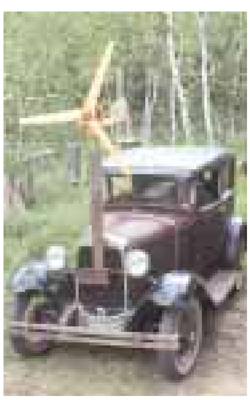
HOME POWER

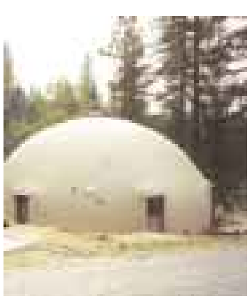
THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #88

April / May 2002

Features





10 High Desert Solar

California energy crisis? Yehuda Shapira decided to help out by paying for half of a 5,760 watt of grid-intertied photovoltaic system. The state of California paid for the other half of this system that pumps electrons into California's grid...backwards through Yehuda's meter.

22 Playing Woodwinds

In one day, Dan Bartmann & Dan Fink built a fully functional wind generator (including the alternator) from wood. Whether your goal is an educational model or functional power, you've GOT to check out this project!

46 Home Sweet Dome

J. Oliver wanted an off-grid dream home in the woods, just like anybody. He came up with an energy and financially efficient solution—an inflatable-form concrete dome.

54 Lights, Camera, Solar!

DJ Johnson sets an example and spreads the word by installing a PV system on his home, and simultaneously filming an educational video series for broadcast on public television.

Features

70 Solar Remote Telephone

Rob Savoye powers both ends of his radio-telephone with PV. His stand-alone base unit runs on a portable system hiding unobtrusively in the woods.

Solar Thermal

34 Homebrew Drainback

Jay Peltz has only basic plumbing skills, but that didn't keep him from building this fully successful solar drainback water heating system. You can too.

62 Get Out of the Kitchen

Jennifer Barker has been a missionary for solar cookery for years. Here, she explains the basics of different ovens, cooking techniques, and even offers some recipes. Yum!

GoPower

92 A Boy and his Car

Not willing to let his 95 years stifle his hands-on history, Frank Silveria converts an '87 VW Jetta to electric.

98 Bits, Pieces, & Gizmos

Mike Brown tells us where to get all those random parts needed to build an electric vehicle.

On the cover: Erich Stephens and Gene Plunkett install PVs on DJ Johnson's house as a TV camera crew films.

Guerrilla Solar

82 **Guerrilla 0019**

This guerrilla overcomes grid deficiencies to get his 240 watts of PV and two MicroSines to perform.

Homebrew

74 **Get Out the Lead**

Soldering how-to.

Things that Work!

88 **Top-of-Pole PV Mount**

Direct Power & Water's PV mounts are quick and easy to install, and strong too.

Book Review

104 ***Insulation Handbook***

Insulation is one of the most important elements of residential energy efficiency. Richard Bynum's book is a nonbiased encyclopedia.

Columns

106 **Word Power**

Mythical units.

108 **Power Politics**

Macro-Enronomics 101.

112 **Independent Power Providers**

Tracking the elusive Xantrex. Taming the wild Trace.

More Columns

116 **Code Corner**

Choices, ethics, quality, and the code in renewable energy systems.

118 **Rain Dance?**

Kathleen sings an ode to the rains & snow that provide their electricity during the winter months.

124 **The Wizard**

Power from the feds, not to them.

134 **Ozonal Notes**

Card sharks, loan sharks... but power sharks? How trading energy as a commodity has opened it up to fishy trading.

Regulars

8 **From Us to You**

80 ***HP*'s Subscription Form**

81 ***Home Power's* Biz Page**

120 **Happenings—RE Events**

126 **Letters to *Home Power***

138 **Q&A**

140 **Writing for *Home Power***

142 **MicroAds**

144 **Index to Advertisers**

Access and Info

Access Data

Home Power
PO Box 520
Ashland, OR 97520 USA

Subscriptions and Back Issues:
800-707-6585 VISA / MC
541-512-0201 Outside USA

Advertising:
Phone: 800-707-6585
or 541-512-0201 Outside USA
Fax: 541-512-0343

E-mail: hp@homepower.com
Web: www.homepower.com

Paper and Ink Data

Cover paper is 50% recycled (10% postconsumer / 40% preconsumer) Recovery Gloss from S.D. Warren Paper Company.

Interior paper, Pinewood Web Dull, a 55# 50% postconsumer, ECF, manufactured by Crown Vantage, a peroxide/oxygen based mill in St. Francisville, Louisiana.

Printed using low VOC vegetable based inks.

Printed by

St. Croix Press, Inc.,
New Richmond, Wisconsin

Legal

Home Power (ISSN 1050-2416) is published bi-monthly for $22.50 per year at PO Box 520, Ashland, OR 97520. International surface subscription for US$30. Periodicals postage paid at Ashland, OR, and at additional mailing offices. POSTMASTER send address corrections to *Home Power,* PO Box 520, Ashland, OR 97520.

This paper is recycled and recycleable.

If your power bills are rising
And they're gettin' sky high,
You might check for sharks
In your power supply.

If your lights keep going out
And you're tired of their lie,
You might check for sharks
In your power supply.

If your pension plan is worthless
And you wonder why,
You might check for sharks
In your power supply.

If the air you breathe is dirty
And it's makin' you cry,
You might check for sharks
In your power supply.

If it's energy you're wantin'
And the sun's still in the sky,
You won't find no sharks
In *that* power supply!

See *Power Politics* and *Ozonal Notes* for more power shark information.
Go solar—nature's power-shark repellent!

–Rappin' Richard Perez for the *Home Power* crew

People

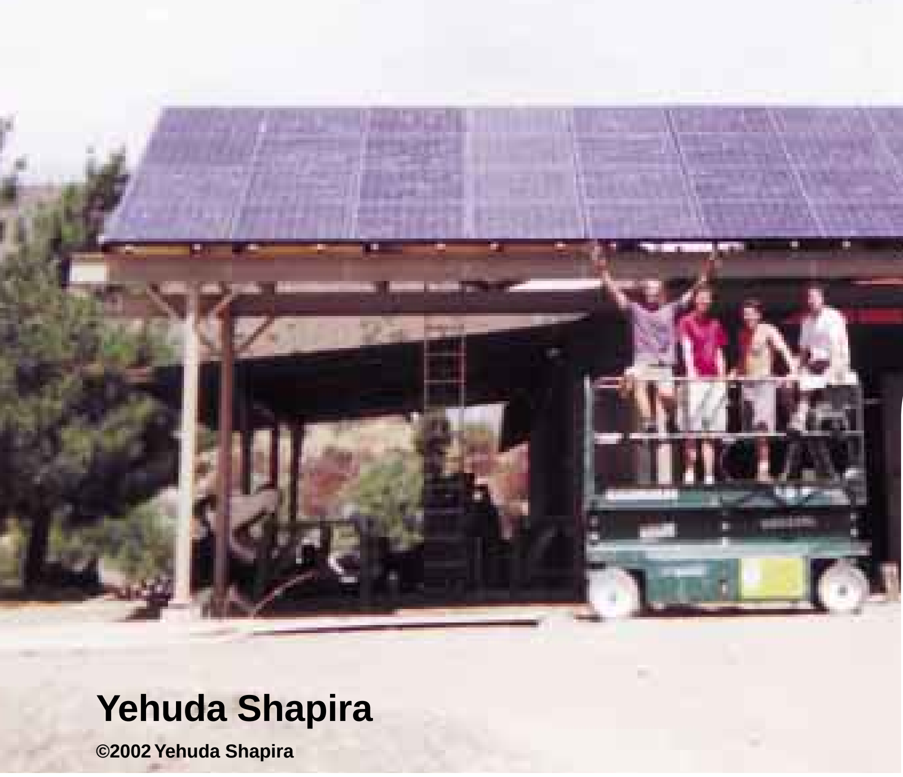
Jennifer Barker
Dan Bartmann
Mike Brown
Sam Coleman
Marika Febus
Dan Fink
Rick Germany
Eric Grisen
Pete Gruendeman
Kathleen Jarschke-Schultze
DJ Johnson
Stan Krute
Don Kulha
Don Loweburg
J. Oliver
Ken Olson
Stephany Owen
Karen Perez
Richard Perez
Jay Peltz
Linda Pinkham
Jason Powell
Shari Prange
Benjamin Root
Connie Said
Rob Savoye
Joe Schwartz
Yehuda Shapira
Erich Stephens
Michael Welch
John Wiles
Dave Wilmeth
Ian Woofenden
Rue Wright
Solar Guerrilla 0019

"Think about it…"

*"People who are willing
to give up freedom
for the sake of short term security,
deserve neither freedom
nor security."*

–Benjamin Franklin

Solar Electricity in California's High Desert




Yehuda Shapira

Yehuda Shapira had his system components prewired and ready for an easy installation day. The proud crew (inset photo, from left to right): Yehuda, Max, Dylan, Barry, and Danny.

California's high desert is an area rich in solar radiation. Last summer, after years of "thinking about it," all the planets lined up correctly for my family and me to build our renewable energy system.

Electricity prices were rising in California, the state's renewable energy rebate program would pay for half the system's cost, and a net metering law was in effect. I was between jobs, and had the time and desire to design and build a photovoltaic system.

I'm a mechanical engineer working in aerospace, and I have tried my hand at a few RE projects over the years. One was building a small homemade wind generator. Another was a 10 watt panel that powered a laptop used in a month-long stay at Lizard Island on Australia's Great Barrier Reef. I've wanted to put together a grid-tied system for many years, and the time was right last summer.

The System

The guiding principle behind my system was keeping it simple and practical to allow minimum maintenance and provide highest reliability. The result is a 5,760 rated watt solar array. The array consists of forty-eight, 24 VDC nominal, Solarex MSX120 panels wired in twelve parallel subarrays, each containing four panels.

The subarrays consist of two sets of two panels. Each set has two series-connected panels, and the two sets are connected in parallel with each other. The whole array is tilted at a fixed 34 degree angle from the horizontal for

Underneath the completed array, the installation is tight and professional. Note the stout rack built by the author.

the best year-round performance. Two Trace ST2500 inverters convert the nominal 48 VDC array output into grid-synchronized 240 VAC, 60 Hz.

The ST2500 provides power and energy information on its liquid crystal display panel. Energy information displayed reflects the watt-hours since DC input was present at the inverter. The display disappears and resets to zero when DC voltage is no longer present at the inverter input. It shows daily energy production summed during that day only. Manual logging of generated energy must be done at the display at sundown each day. A cumulative AC kilowatt-hour meter would be a great addition to this inverter.

A kilowatt-hour meter (not the utility meter) is wired at the joined output of the two inverters. It continuously reads the total energy generated by the array, and never loses its reading. I found a supplier (see Access) that offered refurbished utility kilowatt-hour meters (240 VAC, single phase) and meter sockets.

The meter arrived looking as good as new, with a diagram and clear installation instructions. Installation required bringing the load (grid in this case) and supply (inverters) wiring to the four mounting posts provided in the meter socket box. One additional component of this system is a 240 VAC, 30 amp, fused and lockable disconnect.

System Sizing

Based on our historical usage and budget, we settled on annual photovoltaic energy production of around 7,500 KWH. With this goal, we calculated the realistic output for our locale and the type of system we were considering. At the same time, we tried to match array output with the inverters we chose for the best overall performance.

Shapira Estimated System Loads

Load	*Watts*	*Hrs. per week*	*Avg. WH per day*	*KWH per yr.*
Shop & power tools	2,500	25	8,928.6	3,258.9
House & shop lights	1,500	25	5,357.1	1,955.4
Refrigerator & freezer	400	70	4,000.0	1,460.0
Heating (corrected for winter only)	1,500	15	3,214.3	1,173.2
Radio,TV, & music	500	25	1,785.7	651.8
Cooling (corrected for summer only)	4,000	3	1,714.3	625.7
Well pump	1,000	8	1,142.9	417.1
Washer & dryer	800	8	914.3	333.7
Computers & printer	500	10	714.3	260.7
Irrigation & boost pumps	1,000	5	714.3	260.7
Clocks & phantom loads	200	24	685.7	250.3
Dishwasher	400	4	228.6	83.4
Phones & fax	75	3	32.1	11.7
		Total	29,432.1	10,742.7

Along with the table of estimated loads and their annual usage, we divided the utility meter reading by the number of years since the meter was installed. Since our usage was roughly the same for all of those years, we used that number as our average annual electric energy consumption. Our energy usage includes all the usual suspects found in a modern home. Additional loads include water pumping (submersible well pump) and the booster pumps that are needed for domestic use and for irrigation.

Array size required for a given annual energy production is a function of the following five primary factors.

1. The solar radiation in the geographical location of the array.
This information is available from the NREL Web site for 237 U.S. locations, for flat plate collectors at various mounting angles and tracking situations.

I used 5.5 KWH per meter squared per day for our calculations. This is probably slightly below our actual figure, since Los Angeles is at 5.6 and Dagget is at 6.6, and we are located roughly in between the two locations.

2. The collectors' orientation.
The system designer decides this. For our system, we chose a south-facing fixed array, tilted from the horizontal by the local latitude angle of 34 degrees.

3. Whether tracking is used, and if so, whether it is single or dual axis tracking.
This information will greatly affect your daily KWH production (up to 40 percent depending on location and time of year). Single (east-west) and dual axis tracking array radiation data is presented at the NREL site mentioned above.

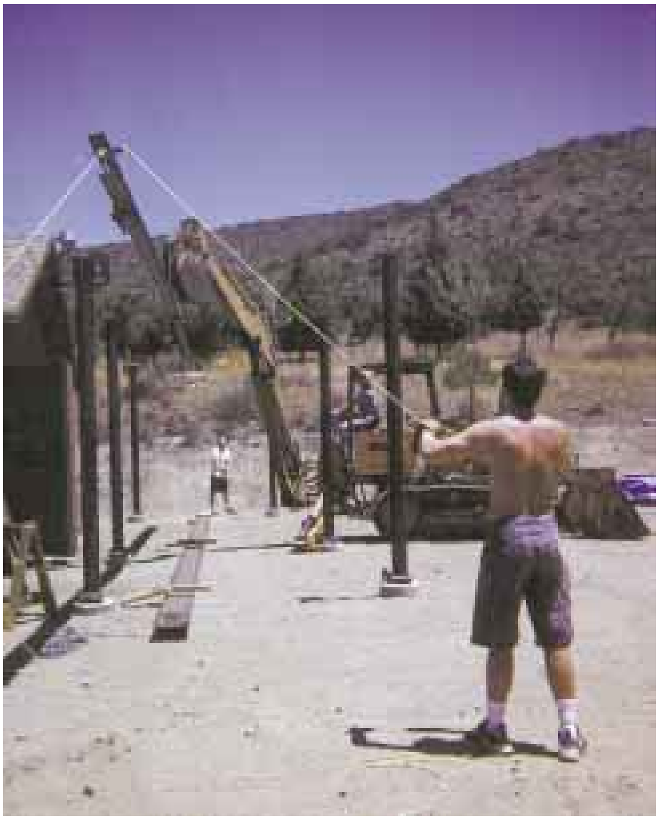
Two primary thoughts formed our decision on tracking. We felt that a purchased and installed dual-axis tracking system wouldn't offset its own cost by much, even at 30 percent gain. And from a reliability point of view, we preferred to stay with the old motto of keeping it simple.

4. Collector efficiency or collector rated output.
The manufacturer provides this information. Output is almost always provided as a peak watt rating. Efficiency is sometimes quoted. If efficiency is not quoted, it can be closely estimated (not actual cell efficiency but the gross panel efficiency) by dividing the rated output by the square foot area of the collector and multiplying the results by 1.076. This is based on the fact that collector published ratings are measured at standard test conditions (STC), employing illumination of 1,000 watts per square meter (92.9 watts per square foot).

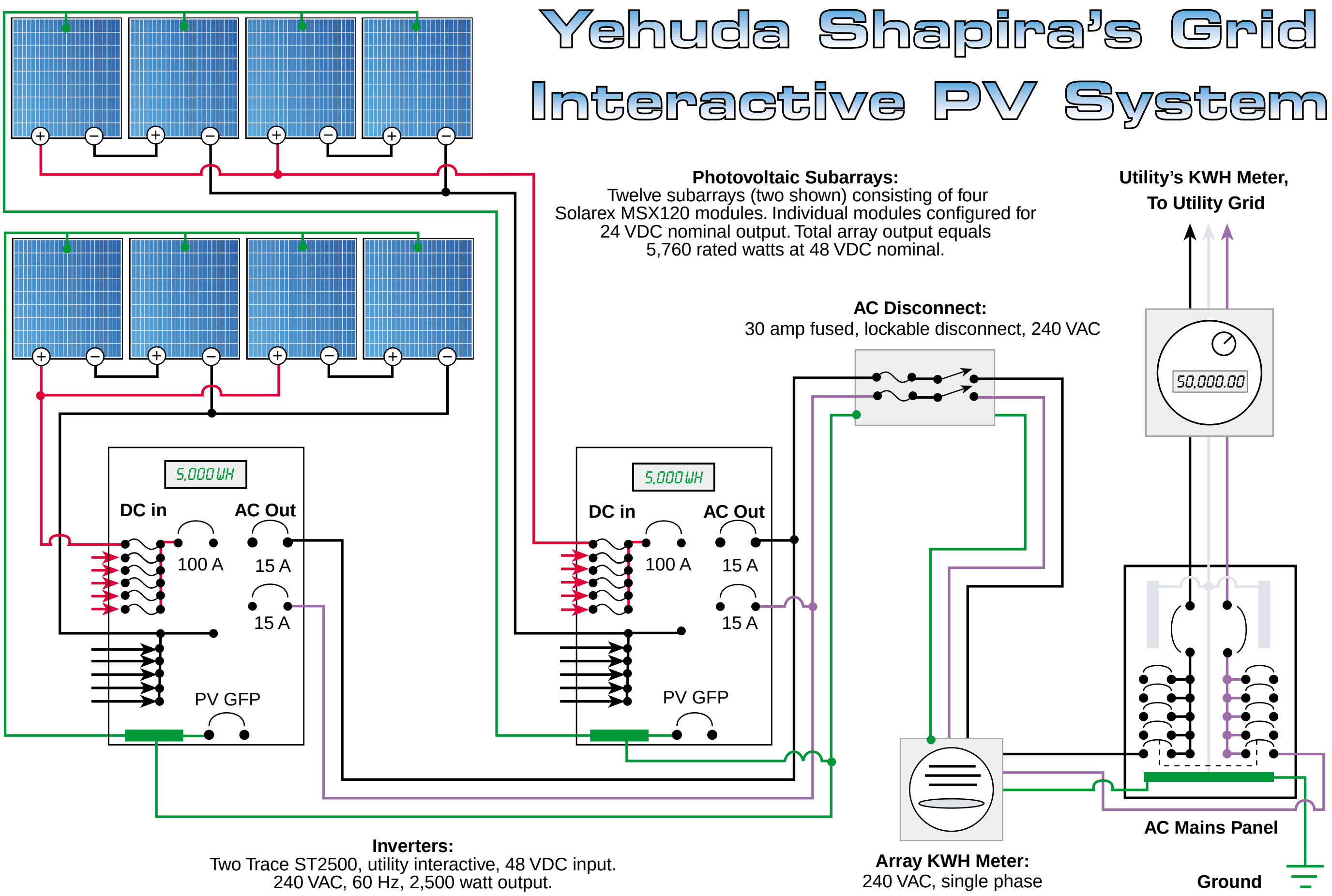
So in the case of the MSX120 panel we chose, the area is 37.63 by 43.63 inches (95.6 x 110.8 cm), or 11.4 square feet (1.06 m^2). Dividing the rated peak output of 120 watts by 11.4, and multiplying the results by 1.076 yields 11.33 percent gross collector efficiency.

Collector efficiency is important when weight is an issue, or space available for collector panels is extremely limited. In most other situations, it doesn't matter whether the output is 11 or 12 watts peak per square foot of collector. Cost per peak watt is what counts. I only wanted to find the collector efficiency so I could calculate the total array area and the number of panels needed.

Raising the 46 foot long I-beam into position.



Welding the newly placed I-beam.



5. System losses.
This is where enthusiasm learns to live with reality as we find out the true meaning of "120 watts peak." System losses include several factors:

Tolerances on collector rating. As mentioned above, the collectors used are rated at 120 watts. The actual factory test output (STC) for the 48 collectors we used ranged from 121.6 to 114.1 watts. The weighted average was 117.8 watts (98.17 percent of rating).

Collector stabilization. Collector output is reduced by about 3 percent due to a "stabilization process" during the first few months of operation, according to Solarex.

Losses due to cell temperature. Factory ratings are for a cell temperature of 25°C (77°F). Actual cell temperatures can and almost always will be much higher. For these collectors, Solarex quotes 0.45 to 0.55 percent reduction in output for each degree Celsius rise in cell temperature. In our case, I calculated a loss of roughly 18 percent.

Wire losses. These losses, due to wire resistance, were calculated from the maximum current rating provided on the collectors' spec sheet. For the longest cable run of 65 feet (20 m), using #10 (5 mm^2) copper wire, the loss is 1.148 volts. While operating the system, it has become clear that the highest power output occurs at about 61 to 62 VDC. BP Solar (manufacturer of the MSX120) explained that peak voltage is temperature dependent, and it will drop somewhat in temperatures higher than STC. So based on the 61 VDC array operating voltage, the wire loss amounts to 1.88 percent.

Inverter efficiency. This depends on the specific inverter, and the point on its efficiency curve at which it is operating. The DC input to the the inverter will vary during the day, and so will the instantaneous efficiency. Xantrex quotes efficiency ratings between 90 percent and 94 percent for loads higher than 500 watts for the ST2500. Since the inverters are sized to operate at above 50 percent of their rated output for most of the time, my guess for annual inverter efficiency was 80 percent.

Summing up all the applicable efficiency factors, I arrived at the total efficiency:

Collector rating tolerance (0.9817) times collector stabilization losses (0.97) times temperature losses (0.82) times wire losses (0.9812) times inverter efficiency losses (0.8) equals total efficiency (0.613). So 61 percent of our collected energy is actually delivered to the grid.

Total desired annual output (7,500 KWH), divided by total efficiency, times gross collector efficiency (0.613 x 0.1133), equals total annual radiated solar energy (107,987 KWH). NREL data for the closest location says that the average (over the year) daily radiation for a flat plate collector tilted south at fixed latitude angle is 0.51

Shapira System Costs

Item	Cost (US$)*
48 Solarex MSX120 modules	$28,328
2 Trace ST2500 inverters	4,730
Welding, steel, & foundation	4,146
Sunlight resistant cable	753
Warranty, 5 year for inverters	645
Wiring, conduit, breaker, & junction boxes	433
Primer and paint	317
Aerial lift rental	135
KWH meter and base	91
Total	$39,578

*Includes 7.5% state sales tax.

KWH per square foot per day. This gives annual radiation of 186.15 KWH per square foot. Dividing the required annual radiation of 107,987 by this available radiation figure of 186.15 yields a collection area of 580 square feet (54 m^2).

Matching Array & Inverters
We chose the Solarex MSX120 mainly for its size (which meant fewer connections between panels), the competitive price per watt, and the manufacturer's long reputation in the field. Using 48 panels of 11.4 square feet (1.06 m^2) each, yields an array totaling 547.2 square feet (50.8 m^2).

Of course, 52 panels would have yielded 592.8 square feet (55.1 m^2), much closer to the target of 580 square feet (53.9 m^2). We went with 48 panels because the Sun Tie inverters each contain a built-in fused combiner box for six subarrays. This made for very clean connections of the subarrays as long as we did not exceed twelve.

At the same time as the collection area was being sized, the inverters were also being considered. Here the maximum possible array output was considered. Since each inverter is connected to half of the array, the maximum theoretical input is calculated as 24 x 120 = 2,880 watts. This is 15 percent higher than the continuous inverter rating. I contacted Xantrex about this, and they said that the inverter will handle this peak power rating even if the power due to secondary reflection from clouds or haze will temporarily exceed the nominal rating by 50 percent.

Reviewing the inverter specification showed that the DC breaker is rated at 100 amps. At a peak voltage of 61 VDC, the breaker will trip at 6,100 watts of incoming DC power. This is 2.12 times the peak power of each half of the array.

The ST2500's on-board AC breaker is sized for 15 amps, 1.44 times the max rated AC output. To date, the highest observed output was 2,340 watts. This occurred at solar noon on a hazy day with air temperature at about 65°F (18°C), a slight breeze, and the sun shining through the haze. So I conclude that the breakers are up to the task.

Wiring & System Layout
Since the array was installed on a dedicated steel frame rather than an existing roof slope, and since there were no obstructions to solar radiation to consider, solar noon was picked as the array direction (the sun is on the east side of the array the same amount of time each day as it is on the west side).

Next we had to choose the right size and type for the twelve cables connecting the subarrays to the inverters. We purchased the panels, inverters, and cables from Solatron Technologies. Our contact there, Michael Diogo, suggested a cable used on other similar installations. Following his suggestion, we used a sunlight-resistant, direct burial, copper cable with two #10 (5 mm^2) stranded wires.

All the wiring was done with the subarrays facing down on sawhorses. Before starting on the wiring, I prepared my wiring schematic for each subarray, showing the wiring details in the exact way that they would appear when being wired. A map showing the location of each subarray was also prepared. Each assembled subarray was assigned a number corresponding to its location on this map. I did this to minimize the chance of wiring and installation errors.

After the wiring of each subarray, I attached the correct length cable to it. The cable was labeled with its subarray number on the inverter end. This way, if any troubleshooting is needed in the future, I can always know which subarray I am dealing with.

Each completely wired subarray was turned over to face the sun and its open circuit voltage (Voc) and short

The ST2500 inverters feed RE to the utility grid.

The subarrays all wired up and mounted on the frames, which are primed, painted, and ready for installation.

circuit current (Isc) were checked. Turning over the subarrays required the help of another person, since each subarray is an unwieldy 13 feet by almost 4 feet (4 x 1.2 m) and weighs 200 pounds (91 kg).

The MSX120 PV module has two rainproof junction boxes on the back. I don't think that I lost any of the little screws or seals that are used on these boxes. But I liked the fact that Solarex gives you a couple of extras with each panel—just in case. Not having to worry about losing these little guys gives you peace of mind, especially when wiring over dirt or in high places.

The Solarex panels came with rain-tight conduit and wiring between the two boxes on each panel. Those connections only had to be slightly altered for the 24 VDC output. The connections between the panels were made with rain-tight conduit and fittings, and wired with #10 (5 mm^2) THHN/THWN stranded copper. Terminals were spade types crimped and soldered. (Yes, I admit it—sometimes I am the belt and suspenders type.)

Working on the junction boxes required some care in removing the knockouts for the interpanel connections. I did not dare use a hammer or any form of brute force on these glass-mounted boxes, so a little scoring with a utility knife was needed before the knockouts gave way.

The twelve subarray cables meet approximately at the middle of the array's high side. At this point, each group of six cables was fed through a 2 inch (5 cm) nonmetallic conduit into a junction box located inside an adjacent shop building. The numbered cables are divided equally between the two ST2500 inverters, also located indoors.

The inverters' outputs are wired in parallel using #8 (8 mm^2) stranded CU wire in 3/4 inch (19 mm) nonmetallic conduit, into a disconnect mounted outside the shop. From the disconnect, the inverters' output is routed through a kilowatt-hour meter into a dedicated 30 amp, 240 VAC breaker in the shop subpanel.

Mounting the Panels

The array is mounted on a dedicated steel frame structure. Each subarray is constructed of four panels that are individually mounted onto two, 13 foot (4 m) long rails. The rails are made of square tubing with holes predrilled in the appropriate locations for mounting four collector panels on each pair of rails. Each collector was mounted using four, 5/16 inch (8 mm) zinc-plated bolts with approximately 1/8 inch (3 mm) between collectors.

I remembered reading a story in *Home Power* that left an impression. It was about a person who had to file all the holes in the rails he prepared for panel installation. Actual hole locations on the panels did not match those shown on the panel spec sheet.

Since I had not yet taken delivery of the panels, again I availed myself of the good services of Michael Diogo of Solatron Technologies and asked him if he could measure the actual MSX120 panel hole locations. He

Subarray to inverter cables (home runs) were premeasured for each subarray.

After installing the first few subarrays, it became second nature. Sheets of plywood kept the scissors lift from bogging down in the dirt.

My sons Barry and Danny and two friends Max and Dylan did a yeoman's job, raising and attaching the twelve subarrays on top of the frame in approximately four hours. Threading the cables and making the final connections took me another day or so. The final connection of subarrays to the inverters was done after sundown, so the modules weren't producing and I didn't have to guard against any unwanted sparks.

Once we passed the county's final inspection, I called Laura Rudison of Southern California Edison. Laura was helpful and responsive throughout this project. She asked that I fax her the signed inspection card, and then authorized the interconnection to the Edison grid. A week later, the formal authorization letter arrived in the mail.

did, and told me that they were to spec, and that no filing was needed, which was correct.

The top and bottom ends of each rail are received by a specially fabricated channel. The rails are bolted to the top channel with 3/8 inch (9.5 mm) zinc-plated bolts, and are welded to the bottom channel. Each channel was fabricated from two identical sections of angle iron cut to length and drilled with through holes for the mounting bolts. A steel template was devised to replicate the exact spacing dimensions required for the placement of the subarrays. Using this spacing template, the channel sections were prewelded to the long horizontal tubing that supports the twelve subarrays.

Welding in the sometimes 100°F+ (38°C+) days, wearing helmet and leather apparel, can get a bit hot. So during particularly hot periods, I would treat myself to the cool job of working inside in the shade bending conduit and pulling wires for the AC side of the system. Or better yet, I'd go and buy some material for the job and enjoy the truck's air conditioning. Ah, the simple joys of life...

Putting It All Together

For lifting the panels to the top of the frame, I rented a scissors lift with a 750 pound (340 kg) capacity, enough for two people, the 200 pound (91 kg) subarrays, and some to spare. These machines are made to roll around on a relatively smooth concrete floor. Since we were working on hard packed dirt, we had sheets of plywood that we moved around to allow smooth rolling, and to provide a more stable surface for the lift.

Following the Xantrex manual, interconnection was not much more involved than operating your microwave. The manual guides you through the final line voltage and array voltage measurements. Once these voltages are found to be within range, you can start the inverter. All that is required for starting is to switch on the three breakers—AC, DC, and ground fault protection. These breakers are located on the inverter's front panel. At startup, the inverter requires a five-minute wait before energy is delivered to the grid.

There was one more thing to do and that was collect and arrange all the project bills, and submit the expense list to the California Energy Commission (CEC). That done, I received reimbursement for one-half of the project cost about six weeks after submitting the claim.

The inverters come from Xantrex with a two-year warranty. The state of California requires a five-year warranty to qualify for the buydown program. Solatron Technologies sold me the additional three-year warranty with each inverter.

How long did this project take? During the design and construction phases, I maintained an informal hour log. The total hours spent on this project—including occasional friendly helpers—was roughly 700. From design to hookup, including revisions, took six months. Actual construction took about three months.

Problems

I was surprised when I discovered that I could no longer listen to my favorite AM radio station, since the inverters

produce too much RFI on the lines. AM reception is impossible near the shop or the house, even on battery operated or car radios.

I contacted Xantrex back in September and then again in December (just before submitting this article) asking for their opinion, but so far have received no response. I have tried wrapping the inverters in a grounded metal mesh, but this made no difference. My hope is that someone reading this knows the cure (beyond switching to FM) and will share it.

The PV array almost completed. Proper planning and attention to detail assured that everything went together without a hitch.

To my pleasure, I discovered that the folks at BP Solar are not kidding when they say that you will get an answer to your question within 24 hours. I had questions about wiring the panels, the variation of voltage with cell temperature, and the manufacturing tolerances used for the collector peak power rating. BP directed me to their online wiring schematics for various panel arrangements. Their answers to all of my questions were prompt, informative, and complete. My appreciation is noted.

The Proof of the Pudding

So, how does it taste so far? In a word—good. The system has been in operation since mid-September. The daily energy production was around 29 KWH a day at first, but has been slowly declining as would be expected based on the seasonal changes. At the end of November, daily production was around 24 KWH on a clear day, and varied between 10 and 15 KWH on partly cloudy days.

Peak inverter output is usually around 4.2 KW, though it was briefly observed once at about 4.65 KW (2.34 KW on one inverter, and 2.31 KW on the other). The inverters turn themselves on in the morning and off at night; absolutely no intervention is required on my part. We found out that we were not immune to the "stand and watch the meter spin syndrome" so aptly described in past *HP* articles. But by now, the meter watching is reduced to daily energy-logging sessions.

We are very happy with the experience. Designing and building this solar-electric system proved to be a bit of a "learn while you do" undertaking, and we took that to be part of the fun. My thanks go to the people at *Home Power,* and to those of you who have written about your projects and experiences. You all participated in my education, and helped me on my solar path.

Access

Yehuda Shapira, Acton, California
yehudashapira@hotmail.com

Solatron Technologies, Inc., 19509 Valley Blvd., Suite 219, Bloomington, CA 92316 • 888-647-6527 or 909-877-8978 • Fax: 909-877-8982
sales@solaronsale.com • www.solaronsale.com

Xantrex Technology, Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-2229
inverters@traceengineering.com • www.xantrex.com

Hialeah Meter Co., PO Box 1047, Hialeah, FL 33011
800-654-0821 or 305- 887-8931 • Fax: 305-887-6542
info@hialeahmeter.com • www.hialeahmeter.com
Refurbished watt-hour meter

BP Solar, 630 Solarex Ct., Frederick, MD 21703
888-BP4-SOLAR or 301-698-4200 • Fax: 301-698-4201
www.bpsolar.com

National Renewable Energy Laboratory (NREL),
1617 Cole Blvd., Golden, CO 80401• 303-275-3000
rredc@nrel.gov
http://rredc.nrel.gov/solar/old_data/nsrdb
Solar radiation data

Industrial Metal Supply, 3303 N. San Fernando Blvd., Burbank, CA 91504 • 818-450-3333
Fax: 818-450-3334 • burbank@imsmetals.com
www.industrialmetalsupply.com
Steel for support structure

AIR-X

THE REVOLUTIONARY NEW GENERATION AIR

AIR-X. It's not just another improvement in a wind turbine, it's an evolution in wind turbine design. The AIR-X is the first micro-processor controlled small wind turbine. In fact, the ***AIR-X*** is so smart it continuously adjusts the alternator to maximize performance and minimize noise.

LOWER STARTUP: *AIR-X* incorporates "peak power tracking" which allows it to begin producing electricity at half the RPM of the AIR 403 meaning more energy for your batteries.

GREATER OUTPUT: *AIR-X's* controller delivers maximum power to the battery by continuously adjusting the alternator loading to maximize alternator and blade efficiency. This ensures the highest possible output at all wind speeds and at all states of battery charge.

SMART CHARGE: It's not just another charge controller. As the battery approaches charge state, the ***AIR-X's*** controller will momentarily stop charging to accurately sense battery voltage. Charging stops automatically when the batteries reach the set point.

QUIET OPERATION: No more flutter control in high winds. One of the most amazing features of the ***AIR–X*** is its ability to control RPM to prevent blade flutter in high winds. This feature allows the ***AIR-X*** to operate quietly in virtually all wind speeds.

AIR X

Southwest Windpower

Renewable Energy Made Simple

2131 N. First Street • Flagstaff, Arizona 86004 USA
Tel 928-779-9463 • Fax 928-779-1485
www.windenergy.com • E-mail info@windenergy.com

WORK FOR PEACE

Dealer Inquiries Welcome

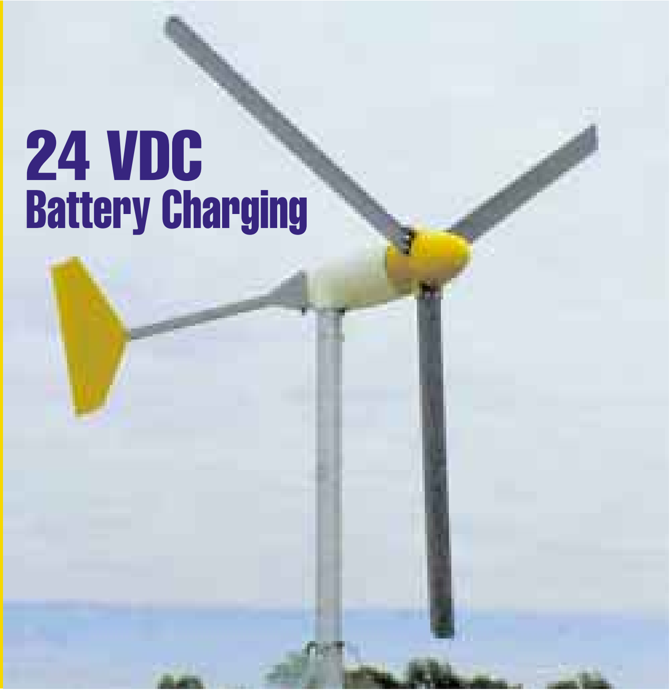
BERGEY XL.1

1000 Watt Home Wind Turbine

Features

- 5-Year Warranty (Industry's Longest)
- Maintenance Free Design
- Excellent Low Wind Performance
- Nearly Silent Operation
- Three High-Strength **PowerFlex** Fiberglass Blades, SH 3045 Airfoil*
- Neodymium Super-Magnet Alternator
- **AutoFurl** "No Worry" Storm Protection
- Fail-Safe Design, No Dump Load Required for Structural Safety
- **PowerCenter** Multi-function Controller
- **OptiCharge** Regulation for Extended Battery Life
- Easy Installation with BWC Tilt-up Towers

*Patent Pending



The all new Bergey XL.1 is the most technically advanced small wind turbine ever. It combines excellent low wind performance and the legendary Bergey ruggedness, at costs well below the lightweights. It comes from the world's leading supplier of small wind turbines and is backed by the longest warranty in the business. The XL.1 delivers on value.

Compare features, performance, price, reputation, and warranties. The new Bergey XL.1 is the clear choice for your home energy system.

$1,695

BERGEY DIRECT

WWW.BERGEY.COM

Or, Call Toll Free: 1-866-BERGEYS

Complete AC "Plug & Play" Systems from $2,995

PowerCenter Controller

- 60A Wind Regulator
- 30A Solar Regulator
- 30A Optional Dump Load
- 24 VDC DC Bus
- Battery Status LEDs

Typical Performance: 5.2 kWh DC per day

4 Times More Energy Than the Air 403[1] **1.8 Times More Energy Than the Whisper H40[2]**

1–Air is a registered trademark of Southwest Windpower, Inc.
2–Whisper is a registered trademark of Southwest Windpower, Inc.

11.2 mph (5 m/s) Average Wind Speed at Hub Height, Rayliegh Distribution. Based on manufacturer's published power curves.

BERGEY WINDPOWER

SIMPLICITY•RELIABILITY•PERFORMANCE

2001 Priestley Ave.
Norman, OK 73069
T: 405–364–4212
F: 405–364–2078
sales@bergey.com
www.bergey.com

The Wood 103

A Wooden 100 Watt Wind Generator

Dan Bartmann
& Dan Fink

The Wood 103 was built mostly of wood in just a day, with very little number crunching. Producing 100 watts in a 30+ mph wind ain't bad for a weekend project!

The initial goal of our project was to build a functional, permanent magnet alternator from scratch, primarily out of wood. When the alternator was together and working, it became clear that wind was the logical energy source for it. This unit (we call it the "Wood 103") is not intended to be a permanent addition to a remote home energy system, but a demonstration of how simple it really is to produce energy from scratch—and to be a bit silly!

Many homemade wind generator designs require a fully equipped machine shop to build. Our wooden version, built in a day, can be made with mostly local materials and simple hand tools in any remote corner of the world. The alternator design is well suited to hydroelectric, human, or animal power. We plan to use it for a series of magnet and electricity demonstrations at local schools, and for future experiments with different energy sources, windings, cores, poles, and rotors. This project will cost you only US$50–75, depending on what you pay for magnets and wire.

Alternator Basics

Electricity is simply the flow of electrons through a circuit. When a magnet moves past a wire (or a wire past a magnet), electrons within the wire want to move. When the wire is wound into a coil, the magnet passes by more loops of wire. It pushes the electrons harder, and can therefore make more electricity for us to harvest.

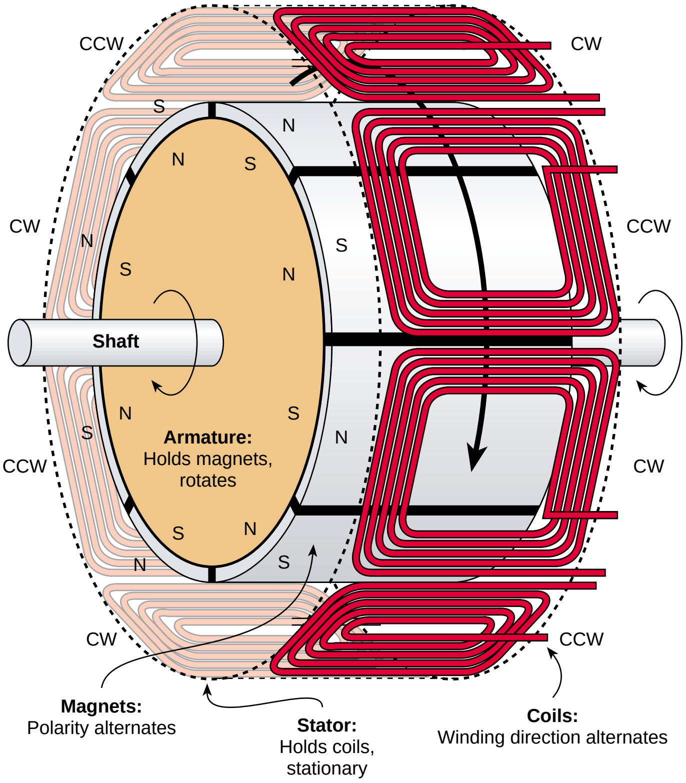
The magnetic field can be supplied by either permanent magnets or electromagnets. All of our designs use permanent magnets. In a permanent magnet alternator (PMA), the magnets are mounted on the armature (also sometimes called the "rotor"), which is the part that spins. It is connected directly to the wind generator rotor (the blades and hub). There are no electrical connections to the armature; it simply moves the magnets. Each magnet has two poles, north (N) and south (S). The magnets are oriented in the armature so that the poles alternate N-S-N-S.

The other half of a PMA is the stator, which does not move. It consists of an array of wire coils connected together. The coils in our stator alternate in the direction they are wound, clockwise (CW) and counter-clockwise (CCW). The coils and magnets are spaced evenly with each other. So when the north pole of a magnet is passing a clockwise coil, the south pole of the next magnet is passing the counter-clockwise coil next door, and so on.

The coil cores are located inside or behind the coils, and help concentrate the magnetic field into the coils, increasing output. The cores must be of magnetic material, but also must be electrically nonconductive to avoid power-wasting eddy currents. The air gap is the distance between the spinning magnets and the stationary coils (between the armature and the stator), and must be kept as small as possible. But the spinning magnets must not be allowed to touch the coils, or physical damage to them will occur.

The Wood 103 has three, 2 foot, hand-carved blades, creating a swept area of 12.5 square feet.

Permanent Magnet Alternator



The more loops of wire that each magnet passes, the higher the voltage produced. Voltage is important, since until the alternator voltage exceeds the battery bank voltage, no electrons can flow. The sooner the alternator voltage reaches battery voltage or above in low winds, the sooner the batteries will start to charge.

Increasing the number of turns of wire in each coil allows higher voltage at any given speed. But thinner wire can carry fewer electrons. Using thicker wire allows more electrons to flow, but physical size limits the number of turns per coil. This also explains why enameled magnet wire is always used in coils. The enamel insulation is very thin, and allows for more turns per coil than does thick plastic insulation. Any alternator design is a compromise between the number of turns per coil, the wire size, and the shaft rpm.

The electricity produced by an alternator is called “wild” alternating current (AC). Instead of changing direction at a steady 60 times per second like standard AC house current, its frequency varies with the speed of the alternator.

Since we want to charge batteries, the wild AC is fed to them through a bridge rectifier, which converts AC to DC (direct current) for battery charging. The alternator may produce much higher voltages than the battery bank does, but the batteries will hold the system voltage from the wind generator down to their normal level when charging.

Design

We had successfully converted AC induction motors into PMA wind generators before. But starting from scratch was truly a first-time experiment. Our design choices for wire size, number of windings, number of poles, blade pitch, and other factors were intuitive rather than calculated.

Every wind generator, waterwheel, and alternator we've built has produced usable energy, no matter how strange the design. The trick is matching the generator, rotor, and energy source. You can do a lot of study and calculation to get there. But if the design is quick, cheap, and easy to build, why not just make adjustments by observing the unit's performance?

If you try this project and change the wire size, magnet type, rotor design, and stator cores, you'd still be making usable energy and have a great starting point for further research. Just change one thing at a time until the unit performs to your satisfaction. We're aware that many design improvements could be made to the Wood 103—and we hope that others will experiment with variations.

Materials Used

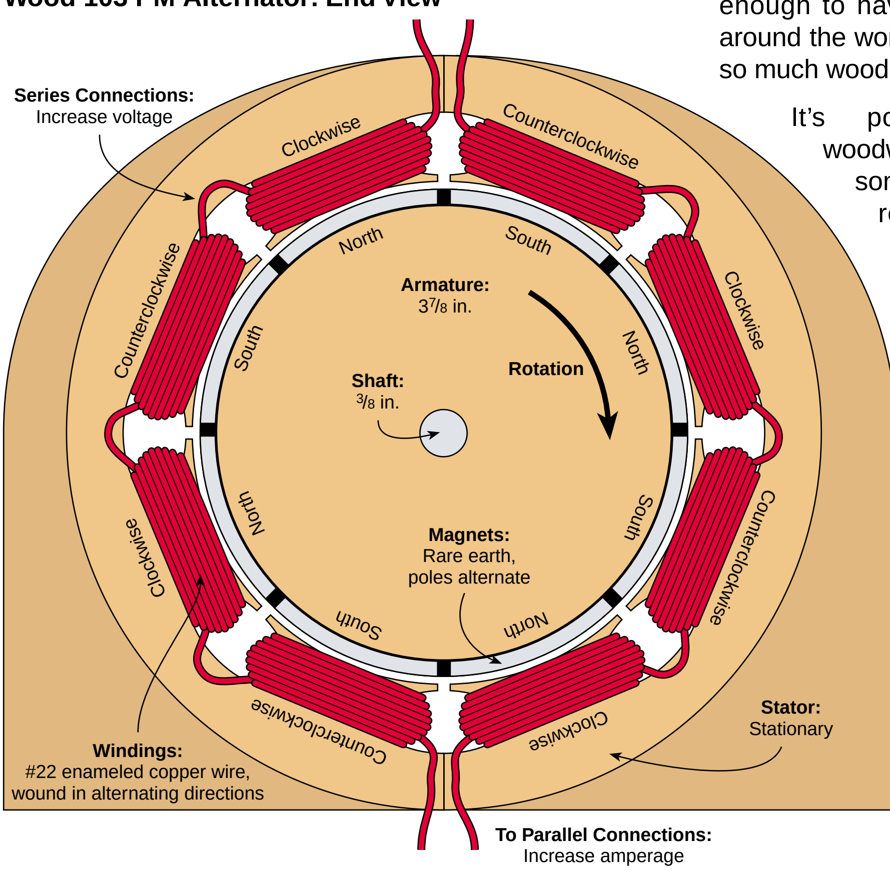
The materials we used are not hard to find:

- Wood, the harder the better. We used pine since it was locally available.
- Copper magnet wire, about 100 feet (30 m), enameled #22 (0.64 mm diameter).
- Eight surplus neodymium-iron-boron magnets, four with the south pole on the convex face, and four with the north pole on the convex face.
- Dirt (magnetite sand).
- A 10 inch (25 cm) piece of 3/8 inch (9.5 mm) steel shaft with a nut on the end to hold the hub on.
- Two, 3/8 inch by 2 inch (9.5 mm x 5 cm) bolts, but these are optional.
- Bridge rectifier, rated for least 15 amps, 100 volts.
- Other supplies—glue and linseed oil.

Wooden Alternator

The biggest problem with building most wind generator designs at home is the need for machine tools—usually at least a metal lathe is required. Headquarters for our business, Otherpower.com, is high on a mountain, 11 miles (18 km) past the nearest utility line. We are lucky enough to have basic tools up here, but many folks around the world don't. That's the main reason we used so much wood in this design.

Wood 103 PM Alternator: End View



It's possible to build human-powered woodworking tools in almost any location. With some patience, only simple hand tools are required for this project. If you want to build it in a day, though, a lathe, drill press, band saw, and power planer can be very helpful!

Building the Armature

The key to the Wood 103's armature is the neodymium-iron-boron (NdFeB) magnets. They are the strongest permanent magnets available. Ours are surplus from computer hard drives. They are curved, and measure about 1 3/4 by 1 3/8 by 1/4 inch thick (44 x 35 x 6 mm). Eight fit together in a 3 7/8 inch (9.8 cm) diameter ring. That's why we chose this particular diameter for the armature.

The magnets are available with either the north or south pole on the convex

The wooden armature holds eight NdFeB (neodymium-iron-boron) magnets arranged in alternating polarity around its perimeter.

face. For this project, you will need four of each configuration. Don't start tearing your computer apart to get these, though! They are from very large hard drives, and you won't find any inside your computer. Check the Access section at the end of this article for suppliers.

To construct the armature, we laminated plywood circles together with glue. The 3 7/8 inch (9.8 cm) diameter wooden cylinder is 3 3/4 inches (9.5 cm) long, with a 1 3/4 inch (4.4 cm) wide slot cut into it 1/4 inch (6 mm) deep to tightly accept the magnets. To assure that the magnets would be flush with the armature surface, we cut the plywood disks a bit oversized, and turned them down on the lathe to the proper diameter. The same procedure was used to cut the magnet slot to exactly the right depth.

Using a firm grip, we carefully press-fit and epoxied the magnets into place. Remember that these magnets come in two different configurations—north pole on the convex face and south pole on the convex face. The magnets must have alternating poles facing out, and this is how they naturally want to align themselves.

Next, we drilled the shaft hole through the center of the armature using a lathe, though it could certainly be done with a hand drill if you are careful to align it perfectly. We roughed up the surface of the shaft with a file before epoxying it into the hole. It should be a very tight fit—we had to gently tap it through with a hammer. This may not be strong enough, and it might be wise to actually pin the armature to the shaft. Time will tell!

Construction without a Lathe

We did cheat by using a lathe to shape the armature, but a coping saw and sandpaper would work just fine. If a lathe is not available, our suggestion is to first cut out the disks, making sure that some of them (enough to stack up to 1 3/4 inches; 4.4 cm) are 1/4 inch (6 mm) smaller in diameter than the rest. Once assembled, the armature will then have a recessed slot for the magnets.

Otherwise some means of "lathing" the slot will have to be devised. It could be done on the alternator's pillow blocks with a sanding block mounted below, or in a drill press. It would also be wise to first drill a shaft hole into each plywood disk, and then assemble, glue, and clamp all the plywood disks together on the shaft before turning.

Building the Pillow Blocks

The pillow block bearings were made from pine, since that's the hardest wood we have available up here on the mountain. Certainly hardwood would be much better. First we drilled a hole slightly under 3/8 inch (9.5 mm) diameter in each pillow block. Using a gas stove burner, we heated the shaft to almost red hot, and

Pillow blocks support the armature. Charred wood creates "carbon" bearings for the shaft to spin on.

Safety Warning!

The large NdFeB magnets in this project are extremely powerful, and can be dangerous. They are brittle, and if allowed to snap together from a distance, they can break and might send sharp shrapnel flying. They are powerful enough to cause painful damage to your fingers if you allow them to pinch you, and can cause malfunctions in cardiac pacemakers if brought too close.

Use safety glasses, gloves, a firm grip, and Zen-like concentration when handling these magnets. Do not get them anywhere near televisions, computer monitors, floppy discs, videotapes, credit cards, etc. They are not toys, and should be kept out of reach of children!

forced it through the holes. This gave a good tight fit, hardened the wood, and made a layer of carbon on the inside for better lubrication. We drilled a small hole in the top of each pillow block, down into the shaft hole, so the bearings can be greased.

After pressing the hot shaft through the pillow blocks, we were very pleased with how freely the armature turned and how little play there was. In a slow waterwheel design, wood/carbon bearings would probably last for years. This wind generator is a actually a fairly high-speed unit, and real ball bearings would be a big improvement. Such bearings could be easily scavenged from an old electric motor of any kind. Wooden bearings were certainly simple, fast, and fun though!

Building the Stator

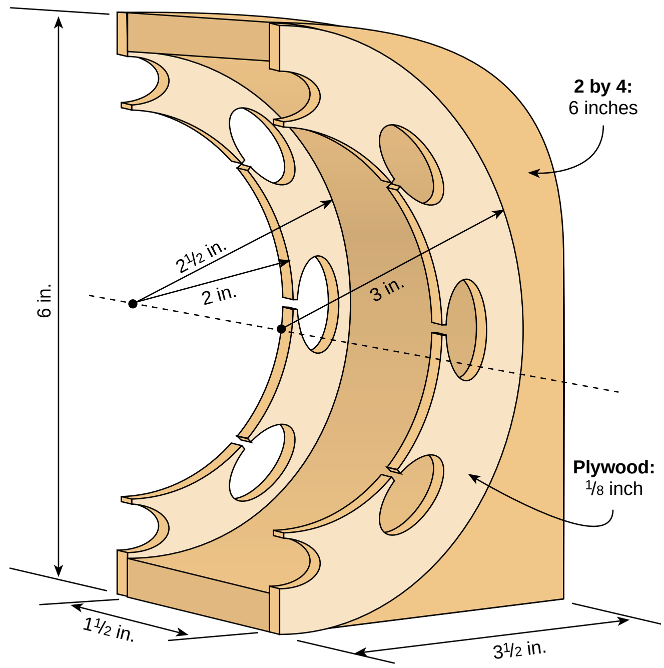
The stator, on which the coils are wound, is made up of two identical halves. Each half is made from 2 by 4 inch lumber, 6 inches long (5 x 10 x 15 cm). A semi-circular cutout with a 5 inch diameter (12.7 cm) was made on each half. The tolerances are pretty tight, but this allows more than a 1/2 inch (13 mm) to fit the coils and core material inside.

On the sides of the 2 by 4s, right over the cutout, we glued thin (1/8 inch; 3 mm) U-shaped plywood "half disks," which have an inner diameter of 4 inches (10 cm) and an outer diameter of 6 inches (15 cm). They have slots cut large enough to accept the coils. These were made with a hand saw, 3/8 inch (9.5 mm) drill bit, and a rat tail file. The coils are wound in these slots, and the space inside and behind the coils is filled with the magnetite core material. There are four coils on each half of the stator, and they must be evenly spaced.

Our twin stator halves are wound with #22 (0.64 mm diameter) enameled copper magnet wire. Magnet wire

The two stator halves—one wound with 100 turns per coil, and one ready to be wound.

Stator Construction



of this type is often available from electronics stores or electric motor repair shops. Each stator half contains four coils. Each coil is 100 turns, and every coil is wound in the opposite direction as its neighbor. It's important to wind the coils neatly and tightly, using a wooden dowel to carefully press each winding loop into place.

Most common alternators use thin steel laminates as cores, to help concentrate the magnetic field through the coils. Magnetism in motion pushes the electrons around in the steel too. The laminates are insulated from each other to block these eddy currents, which would otherwise waste energy.

These laminates are difficult to make in a home shop, so we chose dirt as our stator core—actually magnetite sand mixed with epoxy. It is not as effective as real laminates, but was very easy to use, and available for free by separating it from the dirt in our road. We mixed the magnetite with epoxy and simply spooned it into the open cores. If the cores were left empty (an "air core") the alternator would still work, but with much less power.

Magnetite is a common mineral, a type of iron oxide. It is a byproduct of some gold mining operations, and can sometimes be purchased. As an alternative, we simply dragged a large neodymium magnet (just like the ones we used for the armature) around on our local dirt road on a string for a while, attracting all the ferrous sand, which stuck to the magnet.

Magnetite sand collected from Dan's driveway by dragging a magnet around on a string.

The stator cores are filled with a mixture of epoxy and magnetite sand.

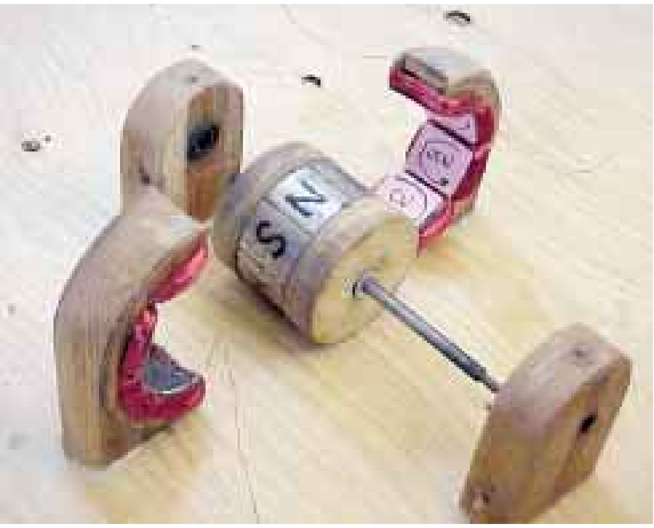
We separated this somewhat magnetic sand into a pile, sifted it through a window screen, and sorted that with the magnet one more time. The remaining black sand sticking to the magnet was nearly pure magnetite. A quick test of any local dirt pile with a neodymium magnet should reveal whether your sand contains magnetite. If not, try dragging the magnet along the sandy bottom of a local river. Any deposits of black sand on the river bottom are most likely nearly pure magnetite.

The clearance between the stator coils and the armature surface is very important. It must be extremely close (within $^1/_{16}$ inch; 1.5 mm) without allowing the magnets in the armature to touch the stator. Our model is actually a bit sloppy—the clearances are more like an $^1/_8$ inch (3 mm). Tighter tolerances would produce more power.

Wiring Configuration

The completed stator consists of two identical sets of four coils. For our wind generator, we connected the stator halves in parallel for more current (amperage). Connecting them in series would double the voltage produced, but halve the amperage. For low wind speeds, a series connection would be the best—the alternator would reach charging voltage at slower speeds. At higher speeds, a parallel connection is optimum for producing the most amperage.

An ideal system would contain a regulator that switched the stator connections from series to parallel when the unit began to spin fast enough. As is the case with many homebrew and commercial wind turbines, we eliminated this entirely, sacrificing a small amount of efficiency for much greater simplicity and reliability. Many people have experimented with such regulators, both solid state and mechanical.



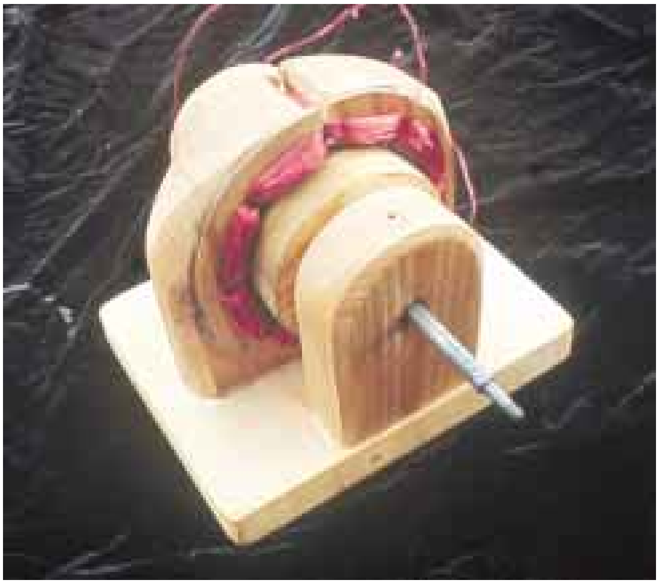
An exploded view shows the armature, stator, and pillow blocks ready to assemble into an alternator.

Alternator Performance

We were really surprised by this alternator's performance. We could easily spin it with our fingers and get 12 volts or higher. A cordless drill attached to the shaft would light up a 25 watt, 12 VDC light bulb easily. This might not seem breathtaking, but considering the simplicity of the project and one-day construction time, we were quite impressed.

Our 100 watt rating for the Wood 103 is probably right on, considering the performance we got during testing,

The finished alternator, ready for a power source.



Almost ready—the wooden frame and tail are attached.

and the way commercial wind generator manufacturers rate their products. Our data acquisition system was pretty simple—multimeters and people with pencils and paper to watch them and record measurements.

With a series connection between the stator halves, the unit reached charging voltage for 12 volt batteries at around 300 rpm. With the stator in parallel, it took around 600 rpm to start charging. When installed on our wind machine, the parallel connection gave us 4.8 amps output in a 25 mph (11 m/s) wind.

Building the Frame

To stay with the style of this project, we chose to build the rest of the wind generator out of wood too. It's a very simple design and should be self-explanatory. It's all glued and pinned with dowels. No bolts are used except to connect the alternator to the frame. We admit that we cheated here!

We did not make any provision for overspeed control, since this was intended to be a demonstration unit for all energy sources, not just wind. A canted tail and spring assembly could be added to control speed during high winds. And of course, making the frame out of surplus steel or aluminum angle would give great improvements in durability.

We also did not include slip rings for power transmission as the wind generator yaws. Instead, we used flexible wire for the first few feet, letting it hang in a loose loop. A piece of aircraft cable cut slightly shorter than the power cable was attached, so if the power wire gets wrapped around the pole too tightly, the connections won't pull loose.

Our normal winds are usually from one direction, and designs without slip rings seem to work fine up here. Wrapping the power wire around the pole is only rarely a problem, and this strain relief cable prevents any damage. Our experience is that if the power cable does wind up all the way, it will eventually unwind itself.

Designing the Rotor

The "rotor" here refers to the blades and hub of the wind generator. We don't profess to be experts in blade design. Once again, we chose our starting point intuitively rather than trying to calculate the proper blades to match our alternator's power curve. Since the blade carving process took us less than an hour for the whole set of three, we figured that any design changes would be quick and easy to make. However, because we glued the blades to the hub, a new hub will be necessary for any blade changes.

There's a great deal of information out there about building blades. Hugh Piggott's Web site and his *Brakedrum Wind Generator* plans are some of the best sources around.

The rotor was built from 3/4 inch by 4 inch (19 mm x 10 cm) pine lumber. Each blade is 3 1/2 inches wide at the base and 2 1/2 inches wide at the tip (9 x 6.4 cm). The three blades are 2 feet long (0.6 m), for a total diameter of 4 feet (1.2 m). The pitch of the blades is 10 degrees at the hub, and 6 degrees at the tip.

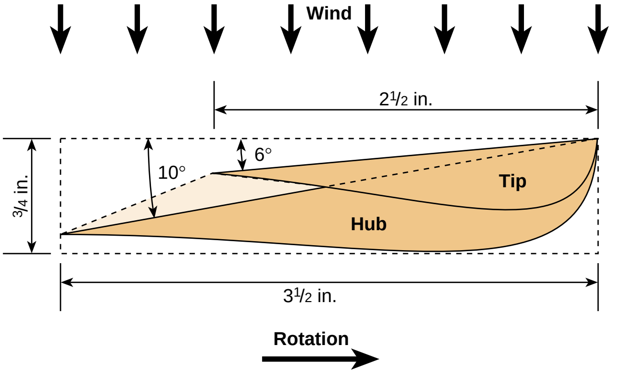
The hub is made from 2 inch thick (5 cm) wood, press-fit and glued to the roughed-up shaft with epoxy. The blades are held onto the hub by one small nut at the end of the shaft, and several wooden pins with glue.

Carving the Blades

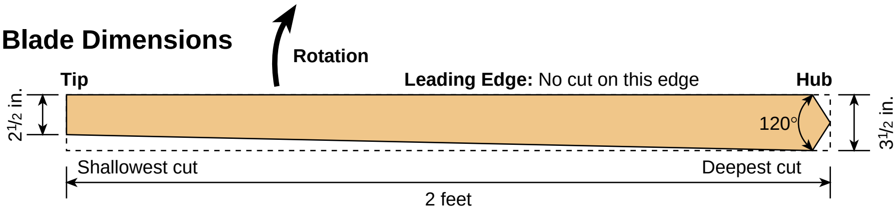
To prepare the blades for carving, we simply drew a few lines so that we knew what material to remove. Each blade starts out life as a 2 foot (0.6 m) long, 1 by 4 (2.5 x 10 cm). Starting from the leading edge of the blade at the hub, we simply used a protractor to lay out how far into the wood 10 degrees of pitch would take us at the trailing edge—about 5/8 inch (16 mm).

At the tip, the pitch is about 6 degrees, so we removed about 3/8 inch (9.5 mm) of material on the trailing edge. We made both marks, and connected the two with a line. We then simply took a power planer, and followed the cut depth line all the way up the blade.

Blade Cross Section



Blade Dimensions



For better accuracy (or if you don't have a power planer), you can use a hand saw to make cuts across the blade every inch or so, down to the cut depth line on the trailing edge and not cutting at all on the leading edge. Using a hammer and chisel, it's easy to break out the chunks of wood to the proper depth. Then smooth the blade down to the proper angle with a hand plane. When the saw kerfs disappear, the blade pitch is correct.

The blade width taper occurs on the trailing edge. We simply used a saw to cut the first taper, and used that first blade as a template for cutting the others. No calculations were made for the airfoil shape on the other side of the blades. We picked a likely looking profile and started cutting with the power planer. A hand planer is fine for this process, too. After everything looked good and even, we sanded the blades and treated them with linseed oil.

Balancing the Blades

To avoid vibration problems and enable easy starting, we made some effort to balance the blades. We considered them reasonably balanced when each blade weighed the same (about 8 ounces; 227 g) and had the same center of gravity. Adjustments can be made quickly with a planer.

Once this is done, and all three blades are assembled on the hub, balance can be double-checked by spinning the rotor and making sure it has no tendency to stop in any one place. This is a quick process, and we certainly were not concerned about great precision here. As it turned out, a small effort in balancing the blades yielded good results, and the machine seems well balanced and vibration free.

Truly, one could write an entire book on blade design, and it can get complicated. Don't worry, though. It is possible to make a very basic blade that will work quite effectively. Often a simple blade with a constant 5 degree pitch from hub to tip and a reasonable airfoil on the backside will work very nicely. If you are interested, explore the books and Web sites listed at the end of this article for more information on blade design.

Testing

For testing, we strapped the Wood 103 to our trusty Model A Ford. The Model A serves as a reliable daily driver, and with the bracket we made, it makes an excellent testing facility for wind turbines. It has a perfectly accurate speedometer, which has been carefully checked by the Fort Collins, Colorado Police Department's radar machines!

We carry a 12 volt battery, a voltmeter, an ammeter, and pencil and paper in the test vehicle. On a still day, we can observe the speedometer and take accurate windspeed versus output measurements on any wind turbine. We've used this rig with props over 8 feet (2.4 m) in diameter. The cost of a good Model A (about US$4,000 if you don't mind a jalopy) is *not* included in the price of this project!

Wind generators should be installed high above human activity. For testing purposes, we've run our generator on low towers within reach of people, and on our Model A. Wind generators have parts that spin very fast! The blades could probably take your head off in a high wind if you were silly enough to walk into them. Make all installations well out of reach of curious organisms. You should treat any wind generator with a great deal of respect. This is not a joking matter, though we always shout "Clear prop!" before we fire up the test vehicle...

Model A Ford—a high tech test vehicle for a high tech wind machine.

The next generation—the WoodAx is for permanent installation, and produces upwards of 300 watts in 30 mph winds.

Improvements

Many improvements could be made to this design. But the intention was to use mostly wood and hand tools, and keep it fast and simple. The wooden alternator is easy and quick to build, but for longest life, it would need to be protected from rain and snow. Maybe a small shingled roof over it?

Using real ball bearings would help friction loss and longevity a bunch. A metal frame and tail would improve high-wind survivability significantly. A furling system to keep the Wood 103 from destroying itself during a gale would be a great addition too. We plan to experiment with many improvements, and we hope this project piques the interest of others too.

Trade-Offs

Designing and building a permanent magnet alternator involves a long series of trade-offs. For example, thicker wire in the windings would give more possible current, but less room for windings and hence lower voltage at the same rpm. Ceramic magnets might be cheaper, but would give far less power than neodymium magnets.

Series wiring on the stator would allow lower rpm at charging voltage, but parallel gives better charging current—and a regulator to switch between the two would be complicated. Using steel laminates instead of air or dirt stator cores would produce more power, but laminate production is extremely difficult.

The trade-offs involved in designing a complete wind generator (or water turbine, or bicycle generator) are even more lengthy and complicated. Wind speed, rotor diameter, number of blades, blade pitch, width and twist, optimum rpm for your winding configuration, generator diameter, and number of poles all factor into a perfect final design.

Improvise, But Do it!

We've tried to demonstrate how easy it is to produce electricity from scratch. Don't let yourself get hung up on complicated formulas, calculations, and machine tools. Even if you make many changes to this simple design, you'll still almost certainly have a unit that makes usable energy for charging batteries.

Then, you can make small improvements until it performs exactly right for your application. And it could be powered by wind, falling water, a human on a bicycle, a dog on a treadmill, or a yak in a yoke!

Access

Dan Bartmann and Dan Fink, Forcefield, 2606 West Vine Dr., Fort Collins, CO 80521 • 877-944-6247 or 970-484-7257 • danb@otherpower.com
danf@otherpower.com • www.otherpower.com
Magnets, magnet wire, bridge rectifiers, free information, and a very active discussion board

All Electronics, PO Box 567, Van Nuys, CA 91408
888-826-5432 or 818-904-0524 • Fax: 818-781-2653
allcorp@allcorp.com • www.allelectronics.com
Magnets, rectifiers, and lots of electronics parts at great prices

American Science and Surplus, 3605 Howard St., Skokie, IL 60076 • 847-982-0870 • Fax: 800-934-0722 or 847-982-0881 • info@sciplus.com • www.sciplus.com
Magnets, magnet wire, surplus electronics, bearings, and other neat stuff

Marlin P. Jones and Assoc., PO Box 530400, Lake Park, FL 33403 • 800-652-6733 or 561-848-8236
Fax: 800-432-9937 or 561-844-8764 • mpja@mpja.com
www.mpja.com • Magnet wire, rectifiers, electronics, tools, test equipment

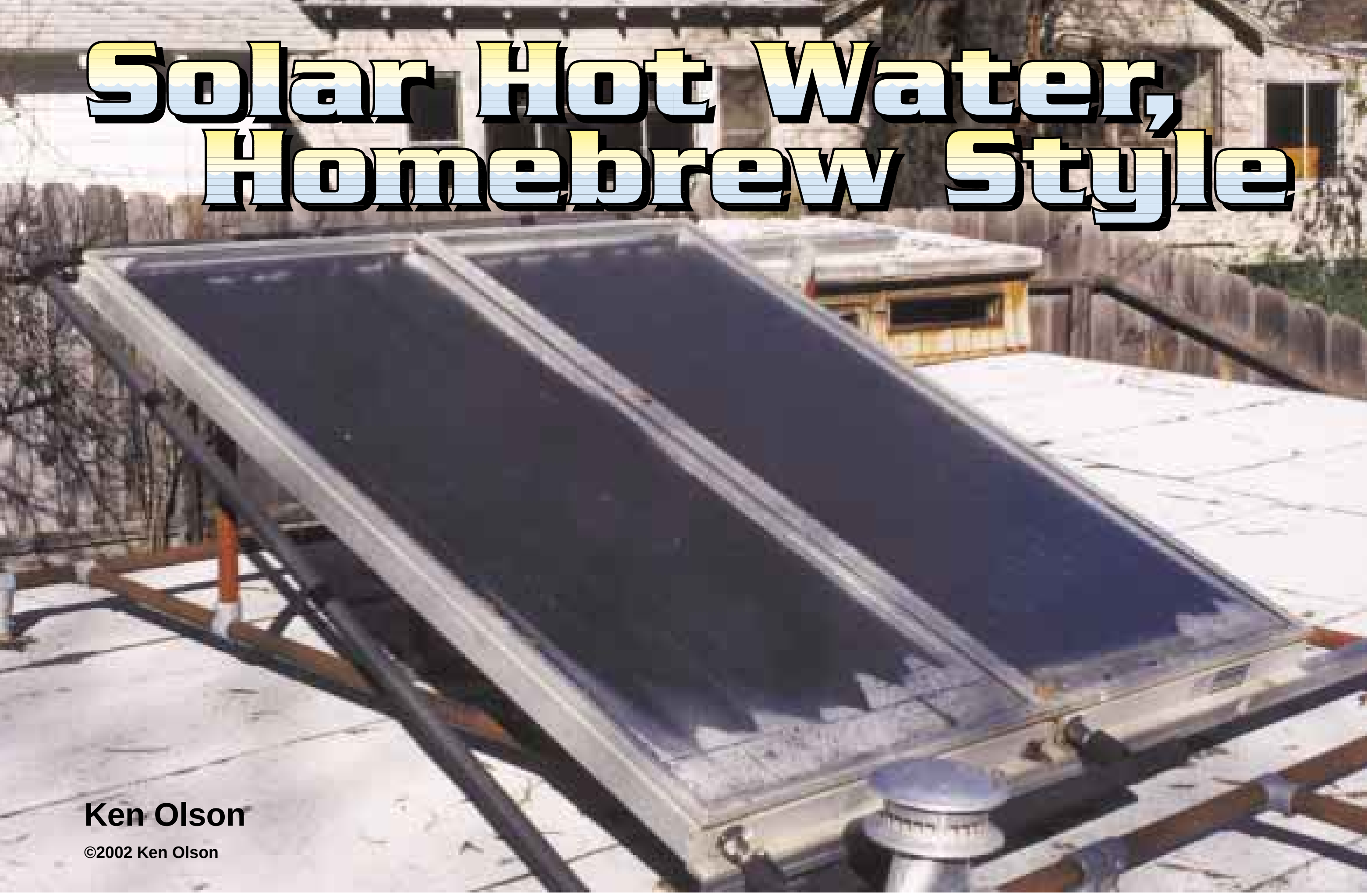
Hugh Piggott, Scoraig Wind Electric, Scoraig, Dundonnell, Ross Shire, IV23 2RE, UK • +44 1854 633 286 • Fax: +44 1854 633 233
hugh.piggott@enterprise.net • www.scoraigwind.co.uk
Wind generator and alternator designs, lots of free information about blade design and carving

WindStuffNow, Edwin Lenz, 10253 S. 34th St., Vicksburg, MI 49097 • 616-626-8029
elenz@windstuffnow.com • www.windstuffnow.com
Alternator designs, parts, useful formulas, free information, and blade design software

American Wind Energy Association (AWEA) discussion board • http://groups.yahoo.com/group/awea-wind-home • Join the list by sending a blank e-mail to:
awea-wind-home-subscribe@yahoogroups.com
www.awea.org

Solar Hot Water, Homebrew Style

Ken Olson



Two, 3 by 7 foot solar collectors make 70 percent of Jay's hot water—that's a 26 percent return on his investment. This home-built drainback system cost only US$800, and required just basic plumbing skills to assemble.

Jay Peltz brews his own hot water, and solar energy is his fuel of choice. The sun goes to work for him each morning, and delivers hot water every day. Jay's homebrew style drainback system meets the need for freeze protection, and is the product of his practical resourcefulness and budget-minded philosophy. The result is a simple design that works.

Solar hot water systems with freeze protection have been covered in two previous issues of *Home Power* (See "Solar Hot Water for Cold Climates: Closed Loop Antifreeze System Components," *HP85*, and "Solar Hot Water for Cold Climates, Part II: Drainback Systems," *HP86*.) Those articles explained the principles of system design, and the function of each of the components. In this article, you will learn how Jay has applied the nuts and bolts of solar water heating principles to a homebrew drainback system.

Climate & Needs

Jay lives in northern California's coastal foothills. The climate is neither sunbelt nor arctic, but the mercury dips below freezing regularly between November and March, and as low as 10°F (-12°C) on rare occasions. Jay decided on a drainback system for its freeze protection, simplicity of design, and ease of installation. With some previous plumbing experience, he didn't hesitate to tackle it, do-it-yourself (DIY) style.

Jay's one-person household has modest hot water needs of 20 to 25 gallons (75–95 l) per day. He uses a little more in the summer when his hot water is 100 percent solar. The average two-person American family uses about 40 gallons (150 l) per day. Larger families use an additional 15 gallons (57 l) per person per day, on average.

Solar hot water system design begins with the daily water consumption figure. Jay knew that starting with a smaller number makes everything easier and more economical. So he addressed the conservation side of the equation first with low flow shower heads and faucet flow restrictors.

Low flow shower heads (under 3 gpm) reduce hot water use by 30 to 70 percent compared to the standard 5 to 6 gallon (19-23 l) per minute guzzlers. Flow restrictors reduce water flow at kitchen and bathroom faucets by approximately 50 percent over standard faucets.

Jay minimizes energy use for hot water in other ways too. He waits to wash full loads of laundry, and selects the cold water wash option on his front loading washer. Front loading washers use 30 percent less water than their top loading cousins. Jay's 1 gallon (3.8 l) per flush toilet saves water too, though only cold water, of course.

Savings Aren't All About Money

Jay does save money with a solar hot water system. He has reduced his hot water heating costs by 70 percent annually, a savings of more than US$200 worth of propane per year by his estimate. At a cost of less than US$800, including the DIY discount, that amounts to a 26 percent return on a tax-free investment—worthy of making headlines on Wall Street. Savings from the first two and a half years of operation paid for his system. Every year after that is a solus bonus (that's Latin for free lunch).

But it's not all about money. Jay saves more than that. He saves carbon—tons of it! His homegrown solar hot water system will avoid spewing 75 tons of carbon into the atmosphere over the next 30 years—a significant one-man stand against global warming.

System Operation

This drainback system uses a reservoir tank with a submerged copper coil heat exchanger. Water within the tank is circulated through the collectors when useful heat can be collected. When the stored hot water is up to temperature, or no more useful heat can be collected, the circulating pump shuts off, and the water drains back to the reservoir tank.

As domestic hot water is drawn from the tap, cold water passes through the heat exchanger, where it is preheated by the solar heated reservoir. From there it passes through a gas-fired, on-demand water heater. If necessary, the temperature is boosted by the heater on its way to the hot water tap.

In the summer, Jay gives his gas water heater a vacation. He shuts it off and uses 100 percent solar heated water. He has also arranged valves in such a way that he can bypass the solar hot water system for maintenance or repair if necessary.

Solar Recycled

Jay didn't have to look far for used solar hot water collectors. The solar heyday of the 1980s collapsed when Ronald Reagan allowed the solar tax credits to expire. Orphaned systems were neglected. Many fell into disrepair for want of basic maintenance. As a result, many systems were decommissioned, and used collectors became opportunities for recycling.

Jay was able to purchase used collectors from a contractor in nearby Mendocino, California. The collectors had been used in a commercial solar hot water system, which had been dismantled. Jay carefully inspected each of the collectors for damage. He used an air compressor to pressure test them for leaks. When the collectors held 50 pounds per square inch (psi) of air pressure for 30 minutes, he knew they were in good working order.

Collectors

The two, 3 by 7 foot (0.9 x 2.1 m), flat plate solar collectors are about the right size for a two-person household, so Jay has more than enough hot water for himself. The collectors are plumbed in parallel for a total of 42 square feet (3.9 m^2) of collector area. This approximates the rule of thumb of 1 square foot (0.09 m^2) of collector area per gallon (3.8 l) of solar storage for his climate.

The Goldline controller and AquaStar backup heater above the drainback tank enclosure.

Jay Peltz' System at a Glance

Item	*Description*
Location	Redway, California
System	Drainback for domestic hot water
Daily hot water usage	25 gallons (95 l) per day
Solar storage tank	50 gallons (190 l)
Collector area	42 square feet (3.9 m^2)
Backup water heating	AquaStar on-demand propane

The collectors are mounted on the roof, facing true south, with the long dimension tilted up at a 30 degree angle from horizontal. Although conventional wisdom calls for collectors tilted to "degrees of latitude" for year-round uses, Chuck Marken of AAA Solar recommends a steeper tilt angle of "lattitude plus 15 degrees" for solar hot water systems. This increases winter performance and lessens variation of seasonal performance. The long dimension of the collector is tilted up as recommended for drainback systems, so the parallel tubes can freely drain.

The flat plate solar collectors consist of a black absorber plate of selective surface copper sheet. The selective surface (discussed in *HP84,* page 48) combines high absorptance in the visible spectrum of light with low emissivity in the infrared spectrum of radiation. These qualities give a selective surface the high heat radiation gain and low radiation heat loss that makes them so much more efficient than flat black, painted absorber plates.

The copper absorber is continuously soldered to 1/2 inch (13 mm) diameter copper tubes that are spaced 4 inches (10 cm) apart and run parallel the length of each collector. A 1 1/4 inch (32 mm) diameter header pipe runs across the ends of the parallel tubes at top and bottom. The two collectors are plumbed together in parallel. The header pipes serve as the inlet and outlet manifolds of the collector array. Jay also tilted the collectors slightly at 1/4 inch (6 mm) per foot so the headers would drain toward the collector inlet.

The rack for the panels is made of 1 1/2 inch (38 mm) steel pipe. The fittings are Kee Klamp brand. These are UL listed, and come in all shapes and sizes. The feet are standard feet for steel pipe. They were attached with ten, 5/16 inch (8 mm) galvanized lag bolts, and were then sealed with mastic.

Jay used these fittings because it was the easiest way to make the rack fit his roof. The roof structure on his older home is 2 by 4 rafters, 24 inches (61 cm) on center, with a 10 foot (3 m) span. There was no way to mount anything in the middle of these!

So he constructed a mount that would attach at the support walls, spanning the 10 foot distance. When he installed his solar-electric array a few years ago, he included the necessary parts to add the future solar thermal panels. Jay is very happy with the way it turned out, though he dreads having to remove the rack to fix the roof!

Drainback Reservoir & Heat Exchanger

The drainback reservoir is also the solar storage tank. Jay used a recycled, 50 gallon (190 l), plastic olive barrel with lid. Water held in the reservoir tank is circulated through the collectors. Domestic water circulates through a copper coil heat exchanger submerged within the reservoir tank.

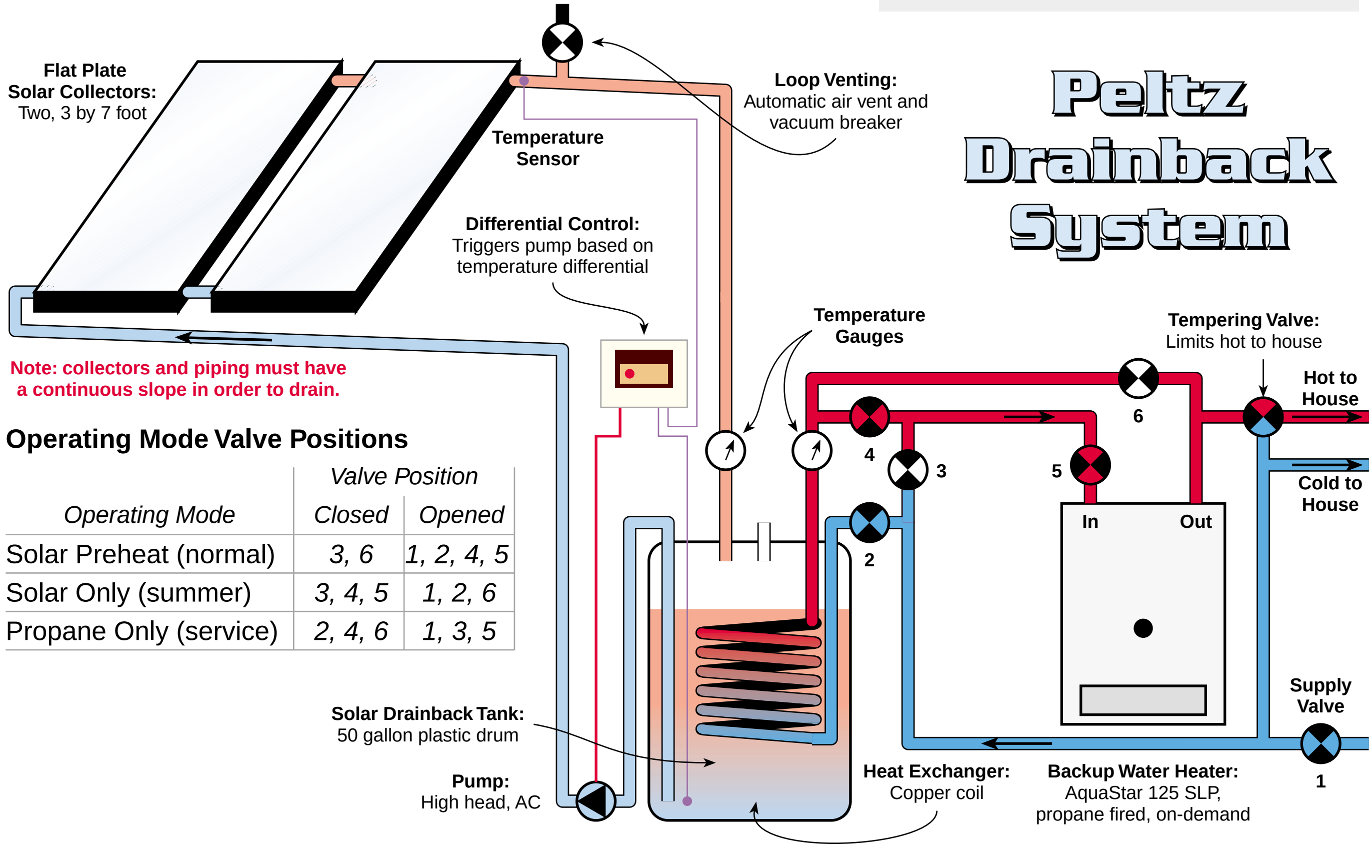
The heat exchanger consists of a 50 foot (15 m) coil of 1/2 inch, soft (type L) copper tubing. This is adequate for Jay's modest hot water use. Larger households would benefit from a greater heat exchange capacity in order to heat water in a single pass. Type L soft copper is purchased in coils and can be easily bent into gentle sweeping curves or coils. Type M is rigid copper pipe, which comes in 20 foot (6 m) straight lengths and is used for most plumbing runs. Both types of copper pipe are readily available at local plumbing supply houses.

As domestic hot water is used, the cold inlet water passes through the heat exchanger, where it picks up solar heat by conduction through the wall of the heat exchanger pipe. The 50 gallon (190 l) reservoir tank is 90 percent full when the system is at rest. When the pump is circulating water through the collectors, the water level drops to approximately 85 percent full.

This approach is a bit different from most drainback solar hot water systems. Three tanks are commonly used: a reservoir tank, a solar storage tank, and a backup water heater tank. The more typical 10 to 20 gallon (38–76 l) reservoir tank simply holds the water that drains back from the collectors when the circulating

The 50 gallon drainback tank is enclosed in an insulated box and surrounded by foam beads.

Peltz Drainback System



Operating Mode Valve Positions

	Valve Position	
Operating Mode	*Closed*	*Opened*
Solar Preheat (normal)	*3, 6*	*1, 2, 4, 5*
Solar Only (summer)	*3, 4, 5*	*1, 2, 6*
Propane Only (service)	*2, 4, 6*	*1, 3, 5*

pump is not in operation. The solar storage tank, with capacity equal to daily hot water consumption, holds the solar preheated domestic water. A conventional hot water heater tank boosts the temperature as necessary for final delivery. A heat exchanger transfers heat from the collector loop to the solar storage tank.

Jay has integrated these functions into one space-saving, energy efficient tank that doubles as reservoir tank and solar storage tank. His AquaStar on-demand heater takes the place of the conventional water heater tank and its associated standby heat loss. Even though Jay's initial cost (US$800) for an on-demand water heater is higher than for a standard water heater (US$250), his savings in gas usage over time will more than make up for the additional expense.

The heat exchanger is placed in the hottest water near the top of tank, but always below the lowest water level. It then heats incoming domestic water with only one pass through the coil on its way to the AquaStar on-demand heater.

The storage tank is enclosed in a box made of 1/2 inch (13 mm), exterior grade (CDX) plywood screwed together with 2 by 2 inch corners. It is insulated with 1 1/2 inches (38 mm) of foil-faced, polyisocyanurate rigid foam on all four sides. The foil face is placed toward the warm side (facing the tank) for maximum effectiveness. The tank has a minimum of 3 inches (7.6 cm) of clearance from the plywood enclosure. Jay filled the voids between tank and enclosure with polystyrene from a beanbag chair.

All plumbing connections to the reservoir tank are made through the plastic lid of the tank. These connections include collector in and out, heat exchanger in and out, and a plastic breather tube that is vented outside. There is also a 1 1/2 inch plastic pipe with cap, used for observation and filling.

Jay installed the breather tube to vent moisture-laden air to the outside, as air and water expand and contract with temperature variations. This venting to the outdoor atmosphere makes Jay's system an open loop, with constant renewed exposure to oxygen. This means that all of Jay's plumbing must be resistant to corrosion by oxidation.

The breather tube is unnecessary in a standard drainback system design that uses a sealed reservoir tank. Drainback systems are typically unpressurized, closed loop systems, unvented to the outdoor atmosphere. Jay's olive barrel has an unsealed top, which would have vented moisture into the insulated tank enclosure. So he had good reason to vent in this case.

Pump—Head & Flow

Jay used a TACO 009F circulation pump in the collector loop. Since the collector loop is unpressurized, the pump must be able to lift water the total vertical distance

(static head) from the low water level in the reservoir tank to the top of the collectors. The total static head for this system is 11 feet (3.4 m). This Taco pump will lift to a maximum head of 34 feet (10.4 m), which is more than adequate. It is installed at a level near the bottom of the reservoir tank, where it is always below the water level.

The Taco 009F has a cast bronze body that is resistant to the dissolved oxygen present in open loop systems. It provides about 7 gpm (26.6 lpm) flow rate, which is more than sufficient. Solar collectors should have a minimum flow of approximately 0.015 gallons (0.057 liters) per minute per square foot (0.09 m^2) of collector. That translates to 0.64 gpm (2.4 lpm) for this system, which has 42 square feet (3.9 m^2) of total collector area. The high flow rate is typical of drainback systems, a consequence of the requirement for a high head pump to lift water to the top of the collectors. Once the water begins to fall down the return pipe, the siphon effect reduces operating head, and the flow rate increases.

The pump is installed with flanges (hence the designation "F" in the model number) for ease of removal for maintenance or repair. One side of each of the flanges is cast to the pump body. The other half of the flange is connected to the pipe. The two sides of the flange are bolted together to compress an O-ring seal between them.

A Goldline GL-30 controls circulation pump operation.

A sensor measures temperature of water leaving the collectors. Another measures tank temperature.

Controller

The system is controlled by a Goldline GL-30 differential controller. The controller senses the difference in temperature between the outlet of the collectors and bottom of the reservoir tank. When the temperature of the collector outlet is 20°F (11°C) higher than the bottom of the reservoir tank, the controller turns the pump on to circulate water through the collector loop.

As water circulates, it removes heat from the collector and increases the temperature of the water in the reservoir tank. When the temperature differential falls to 5°F (2.8°C), the pump turns off and the water drains back to the reservoir tank.

The controller also has an adjustable, high limit cutout. This will shut the pump off once the reservoir tank reaches a predetermined high temperature. The high limit setting is adjustable between 110 and 170°F (43 and 77°C). Jay has set the high limit to 145°F (63°C) to keep the tank from getting too hot.

He doesn't know what temperature the olive barrel will handle. Will high solar temperatures melt it? The 145°F (63°C) maximum temperature setting is a conservative measure to minimize the risk of using materials with unknown characteristics. So far, so good, after one hot summer. The system has no trouble producing 145°F water on a regular basis.

Chuck Marken says that two commonly used plastic materials are suitable for hot water storage—polypropylene and high density, cross linked polyethylene (HDPE). Polypropylene is the best choice

because it will typically handle temperatures up to about 200°F (93°C) before becoming soft. HDPE will begin to deform at about 160°F to 180°F (°71C-82°C), requiring some support from its insulated enclosure.

The controller uses 10,000 ohm, thermistor-type sensors. The electrical resistance of the thermistors changes as the water temperature changes. At a temperature of 77°F (25°C), the sensor has a resistance of 10,000 ohms. As temperature increases, its resistance decreases. The controller continually compares the temperatures at the sensors, and turns the circulating pump on or off according to the controller's set points.

Jay used a stainless steel hose clamp to fasten one sensor directly to the copper pipe at the outlet of the collectors. The sensor is fastened as close to the collector frame as possible, and is covered with pipe insulation so it measures collector outlet temperature as accurately as possible.

He used #18 (0.8 mm^2) two-wire, stranded, PVC double-jacketed, exterior thermostat cable routed along the pipe to connect the sensors to the controller. Jay soldered the sensor connections to the cable with rosin core electrical solder, and protected them from the elements with heat shrink tubing. The connections were then covered with pipe insulation.

On-Demand Water Heaters

Often referred to as "tankless" or "instantaneous" water heaters, on-demand water heaters do not store water. They await your demand, and heat water only as it is used. This eliminates all standby heat loss, and saves 20 to 30 percent compared to a tank-type heater. Gas models operate at a high efficiency (80+ percent). Units with electronic ignition eliminate the need for a pilot light. Models are available for propane or natural gas, or for electricity.

Operation & Performance

The on-demand water heater is activated by flow rate. As the hot water tap is opened, the heater senses the pressure differential and resulting water flow. This activates the flame to continuously heat water on its way to the tap. Water flows through a high-efficiency copper heat exchanger. The unit shuts off when the flow rate stops as the tap is turned off.

An on-demand heater is rated for the maximum flow rate it will produce. This depends on the maximum BTU input rating of the unit and the desired temperature rise. The higher the incoming water temperature, the greater the flow rate it may produce.

Standard and large units are designed to heat water for the whole house. They typically have a maximum flow rate of 4 to 6 gallons (15–23 l) per minute. This could be a limitation for large families and heavy users of hot water. A single, high flow shower head (4 to 6 gpm; 15–23 lpm) could stress household relationships in the competition for the right to hot water.

A typical on-demand water heater: the AquaStar 125B.

Image Courtesy of Controlled Energy Corporation

The solutions are low flow shower heads (1 to 2 1/2 gpm; 4–9 lpm) and faucet flow restrictors. Water conservation allows the on-demand heater to accommodate other simultaneous hot water uses, such as clothes washers, dishwashers, sinks, etc. Smaller on-demand heaters with flow rates of 1 1/2 to 3 gallons per minute (6–11 lpm) are designed for point-of-use applications, such as a single sink.

Installation

On-demand water heaters usually weigh under 50 pounds (23 kg) and are wall mounted. Gas models have a flue, which must be vented outdoors. Optional power vents allow for horizontal flue runs up to 100 feet (30 m) long for some units.

Some models are designed for open loop domestic water heating applications. Other units are designed for closed loop hydronic heating systems. On-demand water heaters also require a minimum flow rate to activate.

The sensor for the tank was inserted inside the tank, since Jay didn't have a good way to fasten it to the exterior of the plastic tank. With standard steel tanks, the sensor is usually placed in contact with the bottom of the tank wall under the tank insulation. Another approach in drainback tanks like this is to place the sensor at the bottom of a copper dip tube with a cap soldered on the bottom. In this case, the submerged wire connections were soldered and protected from the water with silicon and waterproof heat shrink tubing.

Submerged sensors are more than a little risky, and not recommended. If the water corroded the connections or caused them to come loose, the controller would interpret a high resistance in the storage tank sensor as a very low temperature, causing the pump to run continuously. A short between the two wires (low resistance) would be interpreted as a very high tank temperature, and the pump would not turn on at all. These conditions in the collector sensor would have the opposite effect. Extreme care must be taken to protect the sensors, sensor wire, and connections to ensure that the controller has accurate temperature readings.

AquaStar On-Demand Heater

Jay's system uses a propane, on-demand water heater to boost the water temperature when necessary. The unit is an AquaStar model 125 SLP (S stands for solar; LP is for liquified petroleum, commonly called propane). It is designed to operate with open loop solar hot water systems.

The S model AquaStar is able to sense the temperature of incoming solar preheated water. Then it boosts the temperature of the water to meet its thermostat setting. The AquaStar unit is located very close (2 feet; 0.6 m) to the reservoir tank to minimize heat loss in the pipe. The pipes are well insulated with closed cell polyurethane pipe insulation.

Jay offers his eyewitness account of the AquaStar in operation at the end of a sunny day: "When the hot water tap is opened, the heater turns on full flame height. As it senses the water temperature coming in, the flame height lowers and then goes out. This all takes about 15 seconds or less."

A Unique Open Loop Drainback

Jay's drainback design differs somewhat from the standard closed loop drainback system design described in *HP86.* He has vented the collector loop to the atmosphere to assist with system draining and moisture venting. This drainback system is therefore an open loop system.

An automatic air vent and vacuum breaker are installed at the top of the system. These fittings, not normally installed in a closed loop drainback system, are borrowed from the draindown system design. The air vent allows air to escape as the collector loop fills with water. The vacuum breaker allows water to drain back to the reservoir tank because air can enter at the top of the collector loop when the pump shuts off.

Peltz SDHW System Costs

Item	*Cost (US$)*
2 Solar collectors, 3 x 7 feet	$200
Taco 009F pump	200
Miscellaneous plumbing parts	200
Barrel, plywood, insulation	100
Goldline GL-30, differential controller	60
Total	$760

You have probably experienced the same phenomenon by dipping a straw into a glass of water. Remove the straw with your thumb covering the top end, and the straw remains full even though the bottom is open. Atmospheric air pressure (15 psi at sea level) prevents the straw from draining until you break the vacuum by removing your thumb.

The Case for a Closed Loop Drainback

Automatic air vents and vacuum breakers have a history of malfunctioning in more extreme winter climates with repeated freeze-thaw cycles, snow, and freezing rain. The solution is to eliminate the air vent and vacuum breaker altogether, operate the system as a closed loop, and allow air from the top of the reservoir tank to rise up the collector return pipe to break the vacuum. The vacuum must break without fail.

For this to work properly, several conditions are absolutely necessary:

- The return pipe from the collector outlet must be of adequate diameter to pass air flowing up while water is flowing down; $^3/_4$ inch is minimum, 1 inch is preferred.
- The reservoir tank must allow air to enter the collector return pipe. This requires that an airspace is always present at the top of the reservoir tank and open to the return flow of water.
- The air must be able to freely rise up a constantly steep, sloping pipe (steeper the better) to the top of the collectors.

These attributes will break the vacuum and allow the system to freely drain back. Shallow slopes or dips must be avoided because air can be trapped, preventing water from draining freely. Jay could easily eliminate the air vent and vacuum breaker from his system. He

doesn't need them. His plumbing already meets the above criteria for reliable drainage. Removing the vacuum breaker and air vent would simplify Jay's system, but it will still be an open loop because his tank is vented to the atmosphere.

Plumbing and Roof Penetrations

Jay used $^3/_4$ inch, type M rigid copper pipe on the collector return. The collector supply pipe and all other domestic water lines are $^1/_2$ inch, type M rigid copper pipe. Copper joints and fittings were sweat soldered using 95/5, tin/antimony solder. Lead/tin, 50/50 solder is no longer allowed by most plumbing codes in potable water lines. All pipes in the collector loop and hot water lines are insulated with closed cell pipe wrap that is slit along its length to fit over the pipe. Once in place, the seam is glued.

Penetrations through the roof use a sheet metal roof jack with a neoprene boot. These units are commonly used in the plumbing industry to pass pipes through the roof, while keeping the weather out. On shingled roofs, the sheet metal base slides under the row of shingles above, and over the top of the shingles below to effectively shed water. The neoprene boot fits snugly around the pipe and seals out water.

Avoid nailing the sheet metal base in place unless the nails can be covered by the shingles above. That's easy for new construction, but very tricky for installing on an existing roof. Metal roof systems usually have their own proprietary fittings for handling roof penetrations.

Jay used a plastic pipe insulator at each place where he needed to pass a pipe through wall sheathing, roof sheathing, studs, floor joists, or rafters. These pipe insulators act as sleeves to prevent the pipe from coming in direct contact with wood. This protects the pipe from physical stress and structural damage. It also avoids vibrations in the pipe that can be transmitted through the structure of the building. These insulators are specified for the pipe size being used.

Optional Modes of Operation

Jay plumbed the system so he can operate it without gas backup or without solar input. In summer, he can bypass the AquaStar, turn it off, and run on 100 percent solar heated water. He installed a tempering valve in the hot water line to avoid delivering excessively hot water to the tap. The tempering valve (also referred to as a mixing valve) is adjustable, and is set to limit the water temperature to avoid scalding.

If the temperature of the solar preheated water is higher than desired, the valve will automatically mix cold water to temper the water temperature delivered to the tap. This antiscalding strategy is somewhat redundant with the adjustable high temperature limit on the solar control; but when it comes to safety, Jay says that his "belt *and* suspenders" approach pays off.

Two sheet metal roof jacks with neoprene boots make roof penetrations weatherproof.

Solar Farming

Jay installed his system mostly by himself in about sixteen hours time. Those hours were spread out over the course of a week, and didn't include the time spent rounding up components and materials. Half of that time was consumed getting the collectors mounted on the roof with help from a friend.

Jay is proud of his daily harvest of 50 gallons (190 l) of 145°F (63°C) water. He estimates that this system will provide approximately 70 percent of his annual hot water needs—100 percent in the summer months and 40 to 60 percent in the winter. Jay has measured electrical consumption of about 150 to 180 watt-hours per day to run the pump and provide 24/7 power to the controller.

Do It Yourself?

When it comes to homebrewed energy, you can do it yourself, too. If you aren't an expert but have a sense of practical willingness, issue yourself a learner's permit, study the principles, follow good advice, get some help where you need it, and do it. If you are all thumbs or not quite so adventurous, hire a solar contractor.

Whether you do it yourself or hire a professional, your system should comply with local safety codes. In most places, a permit is required and you'll need to pass inspection. Visit with the local building or mechanical inspector before you get started. You'll probably get some good advice, and it always helps to have a positive relationship with your inspector.

Drainback systems are not rocket science, but they are not forgiving to the careless installer. They are relatively simple, and lend themselves to the well directed, do-it-yourself installer. But if you want your experience to be a pleasant one, you'll take all the good advice you can find and follow it closely.

Access

Ken Olson, SoL Energy, PO Box 217, Carbondale, CO 81623 • Fax: 559-751-2001 • info@Solenergy.org
www.solenergy.org

Jay Peltz, Peltz Power, PO Box 2391, Redway, CA 95560 • 707-923-3477 • Fax: 509-461-6302
jay@asis.com

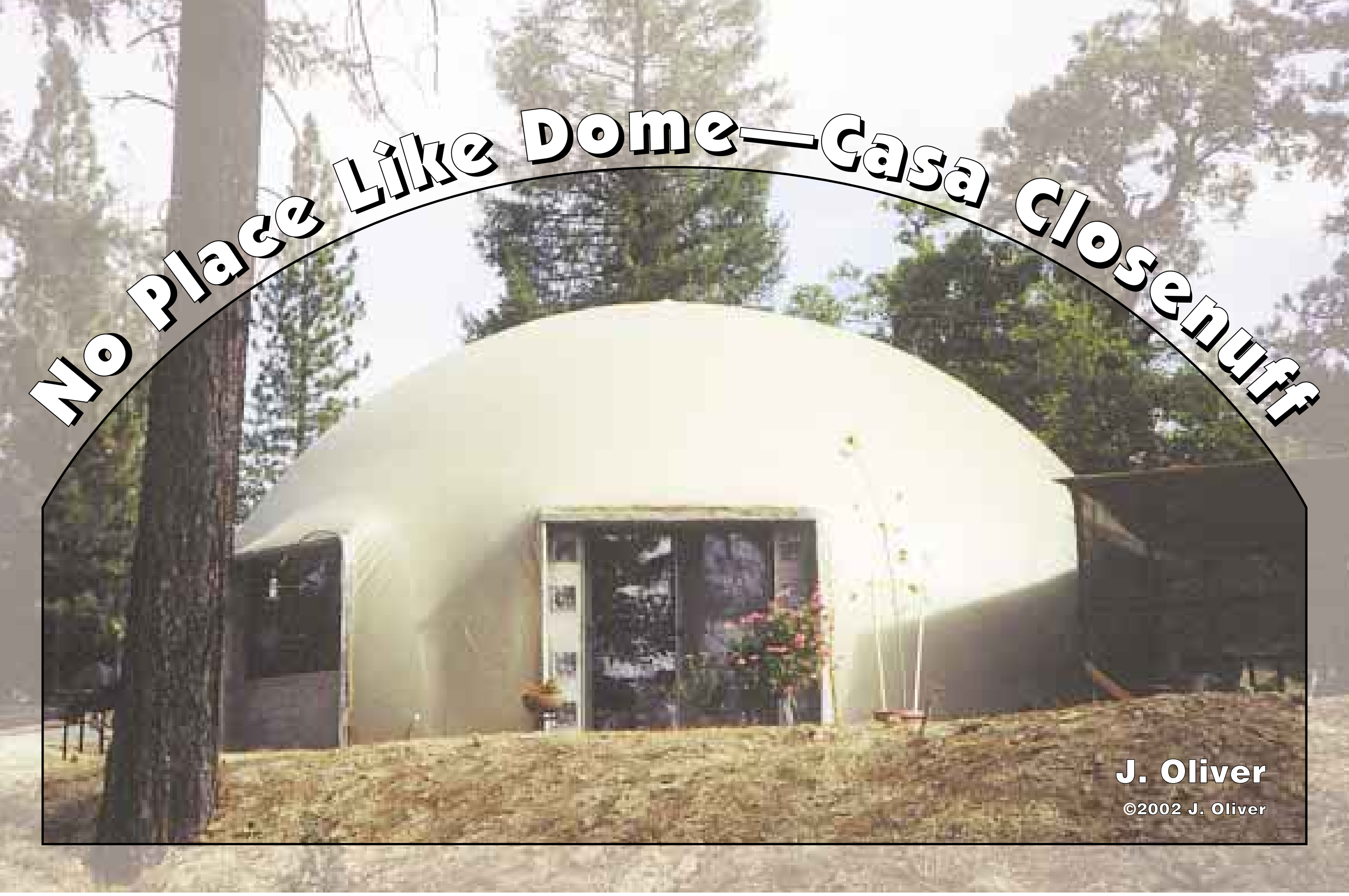
Taco, Inc., 1160 Cranston St., Cranston, RI 02920
401-942-8000 • Fax: 401-942-2360
marcha@taco-hvac.com • www.taco-hvac.com
Hydronic circulating pumps

Goldline Controls, Inc., 42 Ladd St., East Greenwich, RI, 02818 • 800-294-4225 or 401-884-6990
Fax: 401-885-1500 • sales@goldlinecontrols.com
www.goldlinecontrols.com • Differential controls

Controlled Energy Corp., 340 Mad River Park, Waitsfield, VT 05673 • 800-642-3199 or 802-496-4357
Fax: 802-496-6924 • sales@controlledenergy.com
www.controlledenergy.com • AquaStar on-demand tankless water heater

Kee Industrial Products, Inc., PO Box 207, Buffalo, NY 14225 • 800-851-5181 or 716-896-4949
Fax: 716-896-5696 • info@keeklamp.com
www.keeklamp.com • Kee Klamp structural pipe fittings

No Place Like Dome—Casa Closenuff



The south face of the finished dome. The Olivers' dome is powered with renewable energy. It's super energy efficient, and it was built with sweat equity!

My wife and I bought a piece of land in a remote area near Nevada City, California almost fifteen years ago. We planned to build our dream home someday. But we knew that our dream would have its limitations.

For starters, our property is so far out in the sticks that electricity doesn't even reach us. An engine generator would be of only marginal value to us. Nothing spoils the ambience of a peaceful country setting like a roaring generator that costs around US$2 per hour to run.

We didn't consider these limitations to be major obstacles because we had always been big proponents of solar energy and knew that solar-electric (PV) panels would be a part of any home we built. But there was no question that our house would have to be super energy efficient, and most likely could not be built using conventional construction methods. I say that because the climate in our part of California is such that conventional houses require air conditioning in the summer. It's possible to run efficient air conditioners using PV, but doing so increases the required size and cost of the system substantially.

Dream Dome

Thus began our search for energy efficient, alternative housing. We considered everything from underground housing to straw bale homes to adobe construction. But then I saw an advertisement in the back of *Popular Science* magazine, and knew immediately that we had found our dream home—or should I say, dream dome?

The ad was for a Monolithic Dome, a steel-reinforced concrete building known for its superb energy efficiency and strength. Its strength is derived from the materials used in its construction, and its round shape. If you've ever held an egg in your hand and tried to crush it by pushing on the ends, you understand why a dome is so strong.

Not even an earthquake can shake this house from its foundation. In fact, we've experienced two major tremors in the last several months, and while some of our things rattled around inside, the house itself never wavered. It's also a structure that a do-it-yourselfer like me can build.

Inflating the airform is like pitching a huge tent with a concrete footing.

My Do-It-Yourself Dome Building Experience
As for the experience of actually building a Monolithic Dome, it is probably a lot like building anything else. There are moments of exhilaration in various phases of the process as you see the dome getting nearer to completion.

There are also plenty of headaches, and no shortage of snafus, just like any building job. We did it ourselves, but we got a lot of help from a professional builder. And the folks at the Monolithic Dome Institute (MDI) in Italy, Texas, were always on standby and available to give much needed advice, not to mention moral support.

Low tech—digging the trench for the continuous footing.

The first order of business was coming up with a design. That was something my wife Marilyn and I did on the computer. It didn't take much to create the first draft of the plans because they were not terribly complicated, and the process put our personal stamp on the home. Our design called for a hemispherical dome, instead of an elliptical dome, which is not as tall inside. The height was important because we wanted a loft and an office upstairs, meaning we needed a 20 foot (6 m) ceiling above our 40 foot (12 m) diameter house.

Overview of Construction
Construction begins with the placement of plumbing and special electrical conduit, and the pouring of a circular foundation. This round foundation features special anchors around the perimeter that hold the airform in place. The airform is an inflatable balloon-like structure, made of tough, single-ply roofing material.

After inflation, the airform creates the shape of the dome, and construction moves to the interior. At this

Here the airform has been inflated with two large fans. Now the work moves to the dome's interior. The airform will remain as an exterior layer.

point, the inside of the airform is sprayed with a polyurethane insulation material in several stages, until it reaches a depth of about 3 inches (7.6 cm). A grid of steel rebar is then placed onto the foam, making the inside of the dome look like a giant birdcage. Finally, the rebar grid is covered and embedded in a 2 to 3 inch (5 to 7.6 cm) layer of shotcrete. The airform remains in place to serve as the structure's waterproof outer shell.

Foundation & Airform

There are two ways of putting in a slab floor, and we chose the wrong way while attending the school of hard knocks. In retrospect, I—along with the experts—would recommend pouring the floor and the foundation at the same time. We did not do it this way, and had a difficult time working on a dirt floor even though it was completely dry inside at all times. If you want to keep the concrete as your finished floor, simply protect it with lots of inexpensive plywood panels during construction.

When the foundation is completed, there is rebar sticking out of the perimeter. An engineer will determine the shape, size, and spacing of this rebar according to the size of the dome being constructed. The next step is the inflation of the airform. It is important to note that all the necessary building equipment and supplies, especially large items, must be placed inside the building perimeter before the airform is anchored to the foundation.

Here are some tips about what to put inside the airform. You will need rebar, scaffolding, a lift, and all the necessary building materials of any size that won't fit through the door later. If you are off the grid, my advice would be to have a couple of engine generators in case one fails. You will also have to construct an airlock, which will allow you to enter and exit the airform without deflating it. The process of building an airlock is simple and can be accomplished with plywood, standard lumber, and two doors.

We were cautioned about possibly tearing the airform, but discovered that it's very tough. The airform is inflated with two big fans. They must keep running the whole time until the polyurethane foam is sprayed, rebar is attached, and the shotcrete is sprayed and has cured. Once these steps are completed, the entire dome is rigid enough to be a self-supporting structure. A professional team could probably build a dome shell in 30 days. The fans are supposed to be on the entire time.

I decided that once the foam had hardened, the dome was structurally sound enough to turn off the fans until we started spraying concrete. Because I built the dome on vacation and on weekends, there was no way I could leave the engine generator running for the 3 months it took us to get to the final shotcrete application.

I still had to leave the generator running for two, 2-week periods for foam and concrete application. This is a very power-hungry operation. This is probably the main drawback to building a dome off the grid. But we were successful, even using the generator that much. The generator was powered by propane and had a 300 gallon (1,135 l) tank, so we did not run out of fuel during construction.

Spraying Foam

I remembered a Clint Eastwood line from long ago about a man needing to know his limitations. So I contracted to have professionals spray both the polyurethane foam and the concrete on the inside of our dome. For me this was an excellent decision, but

Oliver Dome Shell Costs

Item	*Cost (US$)*
Plumbing & electrical	9,500
Airform material	7,000
Foam insulation	6,400
Shell concrete (shotcrete)	6,000
Shotcrete application	3,100
Foam application labor	3,000
Shell foundation, incl. excavation	3,000
Floor concrete	2,400
Miscellaneous labor	2,000
Rebar	1,800
Propane for generator	860
Doors & windows	700
Inflator fans	500
Total	$46,260

die-hard do-it-yourselfers who want to go it alone are encouraged to do so. Just make sure you prepare completely, and stay in close touch with the folks at MDI. They are experts on every phase of the process, and are lifesavers if you get in a jam and need quick advice.

Briefly, the foam must be applied in several layers to a depth of 3 to 4 inches (7.6 to 10 cm). Once completed, there will be short wire brackets sticking out. Later, these brackets will anchor the rebar in place, and the entire bird-cage-like grid will be sprayed with concrete.

A cautionary note for those who do decide to go it alone with the application of the foam: Because of the chemicals used in the process, outgassing is a problem. The mixing of these chemicals results in the creation of a type of acid that is damaging if inhaled or exposed to the eyes. A full protective helmet and fresh air pumped in from the outside is a safety requirement. The problem dissipates a couple of days after completing the application, but do use caution and avoid breathing these fumes.

J. Oliver tying rebar to the wire brackets that are sticking out of the foam insulation. Layers of shotcrete will be applied in the next phase.

Hanging the Rebar & Spraying Concrete

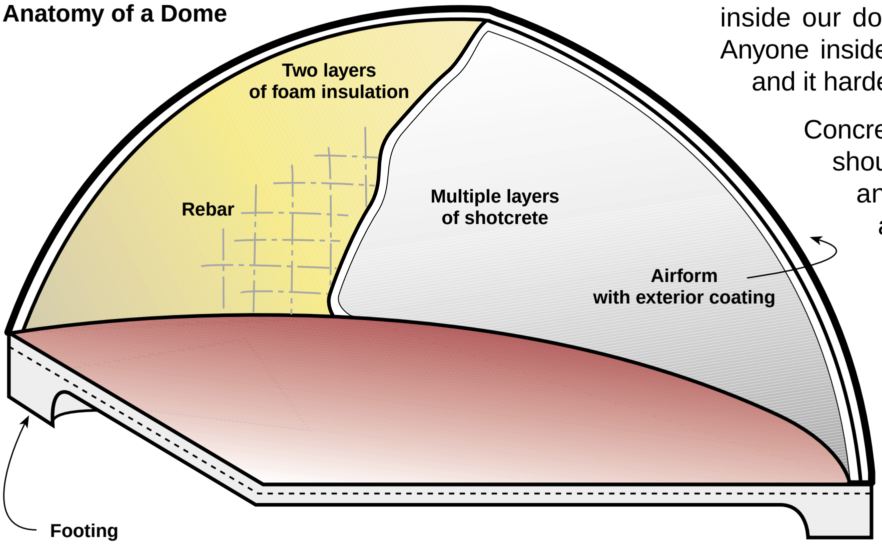
The next step in the process is hanging the rebar. This substantial undertaking means covering the entire interior of the dome with a mesh of the heavy and often cumbersome steel. But putting all this rebar in place is one reason why Monolithic Domes are so tough.

Working on the scaffolding, while looking up and tying rebar into place overhead was tough. It helped me to remember that what I was building would last for a very long time. That perspective kept me going through the muscle aches and tedium that come with any hard job.

It took me and two helpers about a week to put the rebar in place. Our biggest problem was trying to use scaffolding that did not fit the work we were doing. A crew could do the rebar in a couple of days with the right equipment.

Once the rebar is hung and tied, it is time to fire up the shotcrete machine and an air compressor. This job is loud and extremely messy, which is another reason I had professionals do it for me. A huge black fog formed inside our dome, diminishing visibility to almost zero. Anyone inside is covered with a fine mist of concrete, and it hardens like you wouldn't believe.

Anatomy of a Dome



Concrete being what it is, there are some tips I should pass along here. Check, double-check, and triple-check the locations of all doors and windows! It goes without saying that once the concrete application gets under way, these openings are literally set in stone.

Don't be upset about small discrepancies in things like wall thickness. Our walls ended up 4 inches (10 cm) thicker in some places than the plans called for, and there isn't one stretch of surface on

Before: the skeletal beginnings of a kitchen and bath.

After: the completed kitchen.

the dome interior that is exactly the same as areas a few feet away. But to my way of thinking, that is just part of the character of this type of construction. It certainly doesn't detract.

Indoor Air Quality

Don't forget that once completed, your dome will be a virtually airtight dwelling. That's the main reason we put in a skylight that we leave open to facilitate airflow. Because of the airtight properties of domes, my recommendation would be to avoid the use of evaporative coolers or anything that introduces humidity inside. Any moisture generated will have no way of escaping.

Minding interior air quality in domes is critical, and that is another reason I would avoid things like fireplaces and open-pilot stoves. If you do decide to have any or all of these in your dome, take special precautions to design vents that are strategically situated and draw properly.

Interior Floorplan

Once your structure is complete, it is time to put that interior floorplan together, which is a rewarding job. Lots of folks use 2 by 4 interior stud lumber. We chose steel studs, drywall, and concrete block simply because we wanted as little wood as possible inside because of the potential for fire.

Obviously we have some wood, but the only things in our house that will burn are the kitchen cabinets, plywood on the loft floor, and doorframes. Remember, the domes themselves are completely fireproof. (The exterior airform can melt and the foam will char if exposed to direct flame for a long time, but it can be easily repaired if this happens.) The only flammable things inside are combustible materials introduced by the occupants.

Energy Efficiency

The energy efficiency of the dome was the biggest selling point for me. According to MDI, these round, super-insulated homes cost 50 percent less to heat and cool than traditional structures.

At the most basic level, the shape of the Monolithic Dome is one reason for its energy efficiency. The dome simply has less surface area per square foot to heat or cool compared to a square or rectangular home. But the materials used in its construction are a more important component of the energy savings.

Engineers agree that polyurethane foam is one of the best insulating products on the market. On a Monolithic Dome, polyurethane insulation is on the exterior of the structure. It is protected from the weather by the airform material, which is a very durable, heavy duty, vinyl-coated fabric.

The insulation protects the concrete from the actual temperature outside the building. The thermal mass of the concrete also plays into the equation. When the interior of the dome is heated or cooled, the concrete warms up or cools off, and maintains that temperature for a long time.

MDI says that the effective R-value of the walls is R-68. This is based on calculations that take into account many factors that most building department energy calculators do not use. My engineer could only allow a value of R-22 for the purpose of heat calculations performed for the building department.

The house performs much better than the allowed R-value suggests. We had to increase the size of our space heater on our plans to allow for the smaller R-value, but it doesn't hurt to have a heater that is larger than you need anyway. An engineer familiar with Monolithic Dome construction would have come up with

Oliver PV System Costs

Item	Cost (US$)
Kohler genset, 8.5 KW propane	$2,600
2 Arco monster modules, used	2,200
12 ATT Lineage batteries, 8,000 AH, 2.5 V, used	1,200
Powerstar inverter, 1300 W	700
Arco PV modules, miscellaneous used	450
Vector inverter, 1 KW for backup	360
Morningstar controller	200
Todd dual-voltage auto relay	150
Automotive battery charger, used	100
Total	$7,960

a much higher R-value, but I had to use the California engineering specs.

Now that we've lived in our Monolithic Dome home for nearly a full year, I can say with certainty that this type of construction solves a lot of energy-usage problems. On a typical July day, temperatures hit 90°F (32°C) in the shade. It actually got to 100°F (38°C) on Independence Day. But no matter how hot it gets outside, we survive very comfortably with just a couple of fans.

To maintain a comfortable temperature inside our dome in the summer, we open all the windows at night when the air outside is cool. Around 10 or 11 in the morning, we close everything except the sunroof, which we use to keep fresh air circulating throughout the house. Using this approach, our home typically experiences a very small 3 to 10°F (1.7–5.6°C) temperature differential.

The renewable energy system's power shed, PVs, generator, and the dome's north side.

We don't need air conditioning at all, and heating requirements in the winter are minimal. On average, we use 2 gallons (7.6 l) of propane a day for our Vermont Castings direct vent heater, which looks like a conventional cast iron woodstove.

Solar Powered Dome

I wanted to use solar energy for the smaller, everyday energy needs in our dome for several reasons. At the top of the list is the fact that it's environmentally friendly. It's also a renewable and plentiful source of energy, important points here in California where blackouts made recent headlines, and may occur again. And it also eliminates the noise and air pollution associated with engine generators.

We do have to use the engine generator to run our bigger appliances, like the washing machine and well pump. It also charges the batteries when there is not enough sunshine. But given that we live in one of the sunniest parts of the country, we normally are able to limit use of the generator to about an hour a day average in the winter. In the summer, we use it only a couple of hours a week to pump water and wash clothes. Because we are still in the building process, my power tools affect our generator usage dramatically. I may run the generator for five or six hours at a time while working on the house.

Our propane powered appliances include a State, direct vent, 40 gallon (150 l) model PR640PDDS water heater; a GE XL 44 stove; a dryer we got at J.C. Penney; and a Sibir S2721, 7 cubic foot (0.2 m^2) refrigerator. We typically use our Majestic Vermont Castings Radiance direct vent RDV40 freestanding propane heater for two or three hours on cold winter mornings. This year, even with 3 feet of snow and the temperatures outside dipping into the 20s, we stayed nice and warm inside the dome.

I was an avid reader of *Home Power* magazine for years before I built my solar powered home, and it was my bible of sorts when it came time to buy my own equipment. I would recommend that anyone spend the time researching solar electricity. It pays off not only in increased knowledge, but in real monetary savings.

Used PVs
I selected two used Arco solar panels from the Carrizo Plains utility project, along with an assortment of smaller ones that I've been experimenting with as part of my continuing study of solar electricity. These solar panels power all of our lights, a television, two computers, some ceiling fans, and the small appliances that we only use for short periods, like the toaster, vacuum cleaner, and hair dryer.

Each of the two Arco "monster modules" has sixteen individual panels. Each panel has an open circuit voltage of about 6 volts, and an output of 2 to 5 amps. Four panels are wired in parallel, then in series with three more sets of four panels for an output of 12 VDC nominal. Because these panels were used in a sun concentrator system, they have a lot of damage and their outputs vary greatly.

One of these monster modules will give 30 amps at 14 VDC. The other module will give about 16 amps at 14 VDC. I bought the better module from a dealer who had matched and tested the individual panels for output. It was sold as a 380 watt panel. I bought the other module untested from a private party who said he only could get 250 watts from it. These monster modules do not perform as well in the heat as other panels, but work fine in colder weather.

Even though I bought my solar panels used, I still spent US$3,000 for them, along with US$1,500 for the batteries needed to store the energy. Add another US$1,200 for power conversion equipment, and you have a fairly big-ticket outlay, especially for used equipment. Count on about doubling the cost if you buy new solar panels and support equipment. The good news is that new equipment should last at least twenty years, and I expect to get at least ten good years out of my used panels.

Personally, I'm extremely pro-solar, but people should know that sun power does have certain limitations. I get about 3 kilowatt-hours a day from my panels. That level of electricity would cost 20 cents a kilowatt-hour in town, so the solar panels are obviously not generating that much energy compared to the utility grid. But the situation improves with more panels, and the unacceptable alternative for me would be to run an engine generator all the time.

Dome Home for the Long Haul
We call our house "Casa Closenuff." We built the dome and our energy systems with my very limited building and electrical skills, and with no real detailed plans to go by. I would do something, and then step back to see if it worked. Most everything we did turned out close enough, so off we would go to the next step.

We became a little sore from the effort, but we are doing well. We have enjoyed a real and lasting sense of accomplishment in knowing that we built something even Mother Nature will have a hard time knocking down.

It wasn't all smooth sailing by any stretch of the imagination. On the other hand, and most of us know this, nothing good ever comes easy. And it feels pretty good knowing that we won't have to build another dream home for at least a few hundred years.

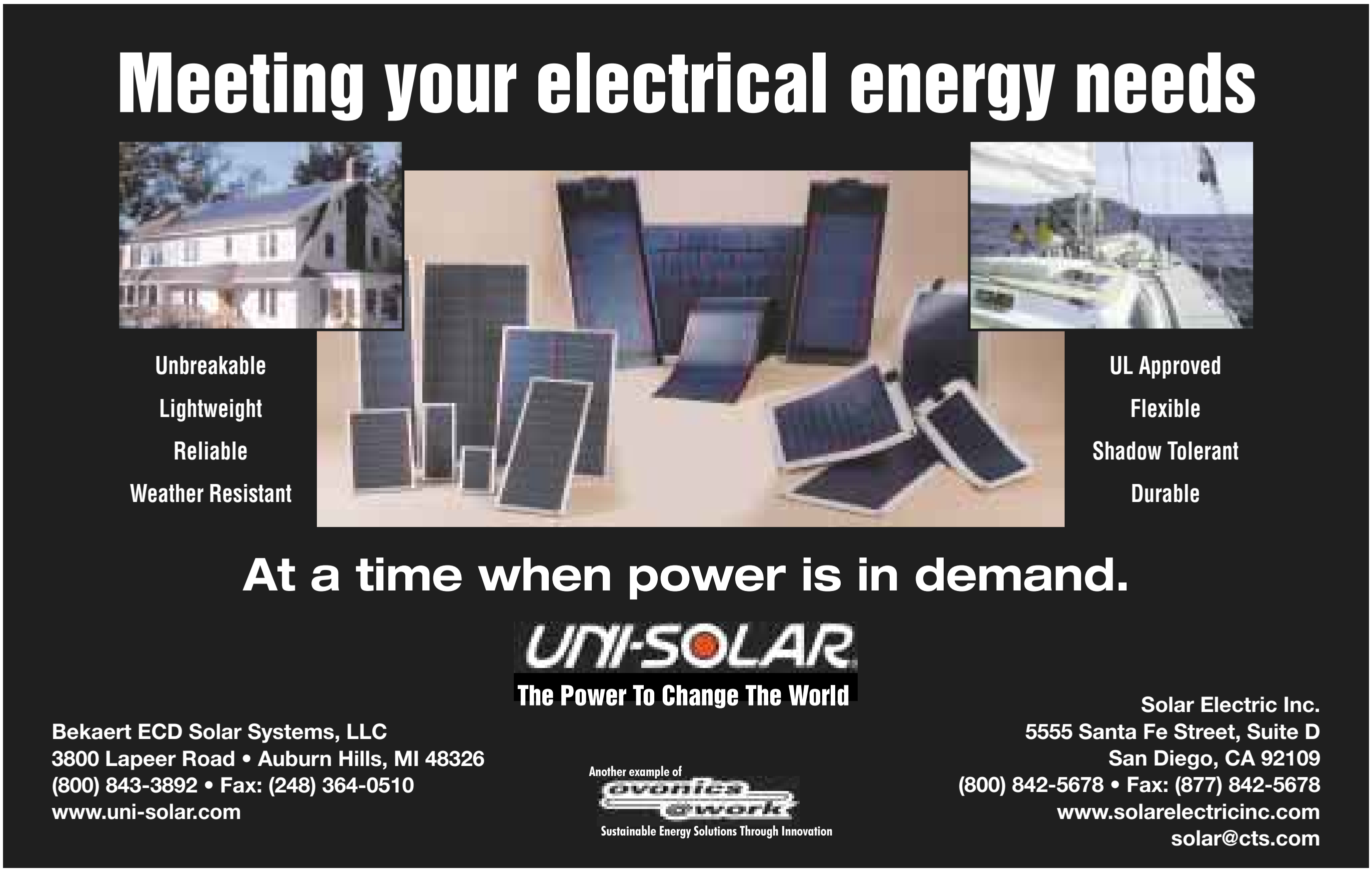
Access
J. Oliver, 21795 Jennet Trail, Nevada City, CA 95959
530-470-0674 • jwoliver@prodigy.net

Monolithic Dome Institute (MDI), 177 Dome Park Pl., Italy, TX 76651 • 972-483-7423 • Fax: 972-483-6662
mail@monolithic.com • www.monolithic.com

UCSC, 1208 N. Grand, Roswell, NM 88201
800-289-8272 or 505-623-9726 • Fax: 505-623-1908
ucsc@ucscurethane.com • www.ucscurethane.com
Foam supplier

Mark Countryman, Countryman Foam Roofing, Modesto, California • 209-545-0886 • Foam application

Photo credits to David Collins and Marilyn Oliver



Meeting your electrical energy needs
Unbreakable
Lightweight
Reliable
Weather Resistant
UL Approved
Flexible
Shadow Tolerant
Durable
At a time when power is in demand.
UNI-SOLAR
The Power To Change The World
Bekaert ECD Solar Systems, LLC
3800 Lapeer Road • Auburn Hills, MI 48326
(800) 843-3892 • Fax: (248) 364-0510
www.uni-solar.com
Another example of
ovonics
@work
Sustainable Energy Solutions Through Innovation
Solar Electric Inc.
5555 Santa Fe Street, Suite D
San Diego, CA 92109
(800) 842-5678 • Fax: (877) 842-5678
www.solarelectricinc.com
solar@cts.com

You can't always rely on the grid
You have invested in an alternative energy generating system. Make sure your battery is NOT your weakest link! Insist on North America's best deep-cycle battery... Rolls
Dual-container construction - eliminates leaks, stray current, and decreases maintenance
Unsurpassed cycling - the most dense active material in the industry - 3300 cycles (50% DOD)
Modular construction - easier installation
Average life expectancy is 15 years - warranted for 10 years
ISO 9002
SGS
Rolls
BATTERY ENGINEERING
1-800-681-9914
Rolls Battery Engineering Ltd. 8 Proctor St., PO Box 671, Salem, MA 01970 Email: sales@rollsbattery.com www.rollsbattery.com

Lights, Camera, Solar!

DJ Johnson

Erich Stephens and Gene Plunkett set the modules in place as the camera rolls and DJ looks on.

When do you get doughnuts with your solar-electric installation? When you turn it into a full-scale, no-holds-barred, prime-time television production. Adding a grid-intertied, 1.2 KW solar-electric system to an older home can be a production of another kind. But when the chance came to combine my career of video production and my interest in renewable energy, I couldn't resist. My home in Providence, Rhode Island was the perfect location.

My dad was one of the first employees of the first TV station in Providence. I grew up watching him directing television shows and producing commercials and news documentaries. I was hooked—at age seven I was editing film reels!

I started working in television full time at age 19, eventually moving from the operations side of the business to the creative production side. That led to editing, graphics, and animations. I have worked for almost every major network and corporation, helping them produce stories, shows, and educational messages.

What's video got to do with energy? When you think about it, it's pretty energy efficient. Three or four people editing video can influence hundreds of millions!

Getting Started

I admit it—I was an Apollo kid. I ate, drank, and slept NASA, and my veins ran with Tang. I remember thinking how beautiful and practical solar-electric panels were. As a grownup, I've always been dedicated to leaving a smaller environmental footprint. When my wife and I bought our house, we thought it would be perfect for solar electricity. Analysis showed that the 1.2 KW system (see sidebar) was affordable, but would also have a real impact relative to our energy consumption. There's room on the roof to do more, and maybe someday we'll add on.

The sound and camera crew working from the crane.

But my goals for installing this system were as much patriotic as green. There's an American flag hanging on my front porch almost every day. It's there because I like what it stands for. It represents a commitment by me and people I never knew to keep a good thing going.

The photovoltaic modules on the roof are my "green" flag. It's not the whole answer to energy, environmental, and political questions, but it's a practical symbol that marks a starting point. I am hoping it inspires my neighbors and passersby to consider PV and other renewables as do-able.

Charged up and ready to change the world, I went to conferences and read everything I could get my hands on. It was during this research that I read a *Home Power* article by a guy from my own backyard. That's how Erich Stephens became our solar energy consultant.

Spreading the Word

I decided to install solar electricity, which was a good start. But I couldn't stop there. I knew I could have a bigger impact than one house. What if I could turn my experience into a learning experience for others, and make the projects we all read about in *Home Power* come to life? Or, what if *This Old House* met *Popular Science*? The result is a 30 minute pilot television program called *On* that showcases up-to-the-minute renewable energy (RE) technology in an inspiring, animated, and eye-popping format.

At first we called the pilot *On the House,* a double entendre on renewable energy systems added onto an existing structure and producing "free" energy. But our research showed there was much more to the energy equation, giving the show new direction. We then realized that the word "on" had so many strong meanings that just the one word would encapsulate the show's intent completely.

Used as a preposition, "on" tells you where something is and what it is supported by. It even conveys how it got there. As an adverb, "on" tells you where something is going. As a noun, "on" describes significance and intention. In this way *On,* the show, describes a way of life, a future, and an evolution. *On* is the acceptance of certain realities and solutions. *On* is an effect that is created by each and every person.

Not Your Typical Installation

I met with Erich and shared all my crazy show ideas and enthusiasms, and he was game to be filmed and quizzed while he was working. As a producer, I've seen the power of video change hearts and minds, as well as educate and inspire. So I set out to do what I do best—make a production out of Erich's simple solar-electric installation.

"When I drove up to DJ's house on the day of the installation, the street was closed with a police barricade," Erich said. "At first, I thought there had been a different kind of shooting! I knew DJ was going to video the installation, but I figured it would just be him and maybe one guy with a camera. Then I found that the street was cut off to traffic, there were tables topped with video equipment in the street, monitors all over, cables snaking across the driveway and lawn, and a huge cherry picker crane sitting in the driveway. To me, it really was a scene right out of Hollywood. Usually someone hands me a key and we're working by ourselves. This was one-of-a-kind."

Erich and his crew handled the attention well. Not many people can stand to work with someone looking over their shoulder. Imagine trying to work with an entire film crew

DJ interviews the installation crew about the module output before the PVs were lowered into final position.

Erich adjusts the mounting bracket so that Gene can do the wiring.

shadowing your every move. The crane gave us some room to operate. It was the best way to get the angles we needed without worrying about getting in Erich's or the installation crew's way, or having a cameraperson fall off my roof. When you're looking through an eyepiece, you tend to misplace your footing. On this project, that could have been deadly.

A crane, camera, and lights can attract attention, so closing off the street was a must. Providence has a very active film production community that fosters good relations with the city and police, so getting the street closed was easy. There was a large staff running around with headphones, monitors, clipboards, and yes, doughnuts! It really was a movie set, minus Julia Roberts.

Ready for Action

Erich says that the filming probably added a day to the installation, due to waiting for the camera or lights to get set up, explaining nearly every move, and occasionally doing something more than once for the sake of a better shot. He admits that it was a little intimidating at first to have a camera and crew following him around and asking questions, but he got into it and had fun.

I think the shoot—and the installation—went really well, and it's always great to work with people who love what they do. We were figuring on splitting the film into four, 30 minute shows, so the hardest part was trying to keep the four separate programs in order in my head. Show one was planned to be analysis; show two, history and technology; show three, panel installation; and show four, inverter installation. We had two days to shoot and represent what was about ten days of research and execution.

My wife was totally supportive. I used our house as an experimental site, and completely transformed the neighborhood for this project. Being the producer, director, and homeowner really gave me the freedom to record the project the way I saw it. And making the video gave me unique access to certain aspects of a solar-electric project, more than your average homeowner. The typical homeowner doesn't get to be on the roof with the contractors, or visit the factory where the panels are made.

As producer of the program, I made it my mission to understand the ins and outs of the PV concept. We did research and feature animations about how PVs work, who invented them, and why an inverter is needed. A tour of the PV manufacturing facility was the next step. Video is a great way of illustrating the hard industrial

Mounting the J-box for the through-the-roof wiring.

The Story Behind the Story—DJ's PV System

Erich Stephens

When we stopped by DJ's house to show him samples of some of the products our company uses, we explained that SolarWrights is actually a division of an earth-friendly, residential remodeling company.

We can't let our main remodeling business get distracted with having to engineer from scratch every solar energy system we install. So we selected one standard, grid-tied PV system and one standard, solar hot water system that works well, given our region's architecture and climate. These systems are what we offer to nearly all of our solar customers.

Rarely is our standard solar-electric system unsuitable for a home that's serviced by the utility grid. And when it is, usually the home isn't a good candidate for solar energy of any sort, anyway. Skilled labor is expensive and hard to get, so we wanted a straightforward system that could be installed on a typical home in one day.

Because utility outages are infrequent and of short duration in our area, and few homes are located away from the grid, we decided that our standard system would be grid-tied, with no battery backup. Fortunately, here in Rhode Island we have a decent net-metering law in place for homeowners. This allowed us to use a standard PV capacity size, since we don't need to worry about sizing a system to a particular home's load. (Though of course, we always encourage conservation and efficiency!)

We settled on a 1 KW system as being large enough to make a significant contribution to the electric consumption of a typical home in our area (about 25 percent), but not so large that it becomes unaffordable for many people. Most homes in our area don't have enough unshaded roof or yard for more than 1 KW anyway.

System Details

The PV system we settled on (and installed for DJ) consists of four ASE Americas 300 watt modules and an Advanced Energy GC-1000 inverter. The inverter has a nominal 48 VDC input and a 120 VAC, 60 Hz output.

We like how the roofing jacks for the modules allow for a quick and easy installation on the asphalt shingle roofs that are typical in our area. The jacks have slots that receive and hold the modules in place without the use of tools. Once they are bolted onto the roof, the modules simply slide into place, and are easily lifted out again if need be. We selected the ASE modules because they are built locally, which has additional environmental benefits.

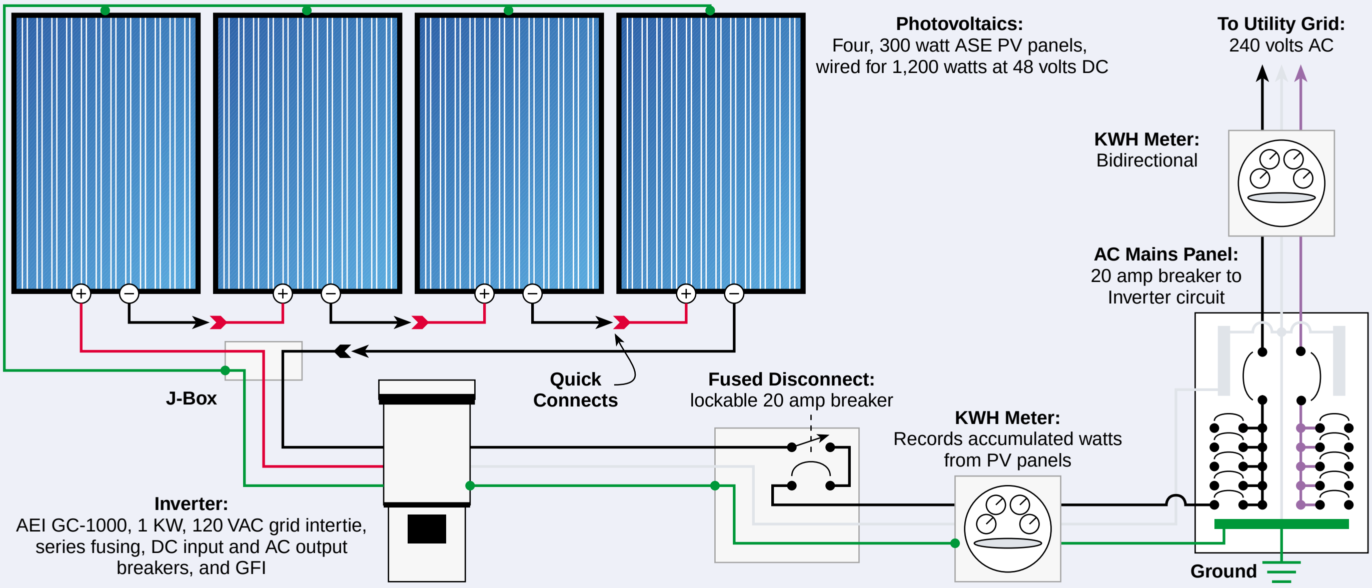
The "quick-connect" cables on the ASE modules enable an electrician to work quickly on the roof. We run the module wiring into a roof-mounted junction box (unseen from the ground), and from there penetrate the roof into the attic. Once in the attic, the electrician uses standard tricks of the trade to get into the basement, where the inverter is mounted. This makes an attractive installation, and the electrician spends his time doing familiar tasks.

Energy Contribution

We always install a standard electric meter to show the inverter's output. This gives customers something to show off to their neighbors, and also gives them peace of mind. Unlike most home systems (such as a furnace or air conditioning), there really is no easy way to see or feel a PV system actually working unless it has a meter.

So our system design was determined as much by business considerations as by technical considerations, and we think this is as it should be. If solar energy is ever to make a significant contribution to our nation's energy sources, installing systems will have to become as mainstream and profitable as any other home renovation.

DJ & Kyle's Grid-Intertie PV System



Gene, master electrician, makes the grounding connections in the junction box.

science of a production process like manufacturing PVs into a few minutes. We visited ASE's plant in Billerica, Massachusetts, and were given a step-by-step tour of the process.

The Show Must Go On

My overall goal for the TV series is to share simple, smart, functional, earth-saving techniques to expand the use of renewable energy. It will explore new systems and technologies to balance consumption and production, and invest in our future. It will promote a lifestyle to protect resources, reduce demand, and increase supply. Each episode will have a project with a mission, and work with experts to solve the problem.

I designed a graphic educational display called the "green gauge" to compare consumption at the project's beginning and end. Part of the program is dedicated to the deployment of other energy saving measures such as compact fluorescent lamps, as well as simple energy awareness. Each show ends with a summary and an evaluation of the project's impact using the green gauge.

The green gauge ties the economics to the ecological, in the same way energy and economy are tied. One of my favorite quotes is by Ben Franklin: "We know the value of water when the well is dry." So my green gauge measures the value of our ecological efforts.

Loads & Cost

One of the first places we needed to make an ecological effort was in our own home. We took a hard look at our loads before and after the installation. We had over twenty lights in the house. Five of them were real offenders. They were 100 watt monsters that we used all the time, and they remained on as "comfort" lights." We found some 20 watt dimmable compact fluorescents, and swapped those out. We knocked down both wattage and lumens, and reduced our overall consumption.

The next challenge was to do something about our bathroom vent fan. This would be left on for hours (sometimes days, since it's our nature to rise, shower, and run off to work). We installed a nice timer switch in the wall—problem solved.

The final step was a cooling system for the bedroom. At a conference, I'd seen a demo blade from a new type of ceiling fan being marketed through Home Depot. The blade design pushed a lot more air than the paddle type. Our goal was smarter use of the watts by using timers, temperature gauges, and lazy man fixes like remote controls. If I was going to take time off from my producing gig, it would be to invent a whole house

Gene explains the inverter, meter socket, and lockable disconnect to DJ.

remote control system. It would be great to sit down and watch my show without wondering if I'd left that light on in the laundry room.

SolarWrights sells our system at US$10,000 for a typical installation. They do a site visit to determine if an installation is typical, and ours was. They also charge the Rhode Island Renewable Energy Collaborative US$3,600 (US$3 per watt) for putting the system in, as part of the state's PV buydown program.

Rhode Island has pretty good tax incentives for solar energy. (Thanks to efforts by SolarWright's president, Bob Chew!) I'll be able to deduct 20 percent of the system cost off my state income tax. I'll get a full refund of the sales tax I paid on the components, and I won't be charged property tax for the solar-electric installation.

The Ultimate Payoff

Our system was commissioned on the summer solstice, June 21, 2001, and we've been really pleased. We anticipated 146 KWH a month, and hit that right on the head. I look at the dedicated KWH meter every week or so. The system spins the utility meter backwards all day long, and has exceeded my expectations in every way. It has made us more proactive in our energy conservation, and has allowed us to bring the renewable "religion" to neighbors and friends.

Measuring my home using the green gauge really brought the efficiency and conservation point home. During the last ten years, we've added all sorts of helpful energy-consuming appliances. Now we have added a *supply* appliance and changed our habits and minds about demand.

It's holistic. We are really paying attention to where energy waste is happening. A dollar's worth of conservation applied under the roof is worth three to five dollars on the roof. We turn off lights and appliances as soon as we can. We're competing—it's like tetherball. We try to keep the ball going in the green direction as much as possible. It's personal. It's "our" energy.

Now we know that when we come home and find a fan running or light burning that we have foolishly wasted our clean energy. It's like discovering you have a hole in your pocket—you don't mind that you lost the lint, but you really hate it when you lose the coins.

The result is a new awareness. We use electricity every day. When we use it wisely, we will be using more PV energy and less grid energy. That gives us a better return on our investment. We also see the difference in our bill. We've gone from a monthly average of 536 KWH to a new average of 246 KWH.

DJ and Kyle are proud parents of a new PV system.

Ripple Effects

As an added bonus, everyone working on the video project became more aware of energy issues. The first thing I noticed was the equipment in our power-hungry office being turned off as soon as we were done with it. Some folks insulated their houses, and everyone has deployed compact fluorescent lightbulbs.

Recently my wife and I were out working in our garden when our neighbor came out and started running his electric hedge trimmer. We walked over to our meter and noticed that it was cranking backwards, sending energy back to the grid. We both realized that we were helping him trim his hedges without lifting a finger!

What's Next?

We're really excited about the TV show's potential to make renewable energy more widely known and accepted. Whether we're working on a house, office, or farm, we'll expand beyond solar energy into each project's supply and demand issues, taking several episodes to complete each project.

We're marketing the pilot aggressively and negotiating with public television about picking up the show. I point out how alarmingly dependent we are on fossil and nuclear energy, and ask if they want to be known as the people who helped change that. We presented our pilot to the top fifteen PBS stations in the country, and the response was very positive. We have since presented to more than 350 public television program managers. Their nominations and a funding partner should bring the show to audiences nationally by late spring.

We've also edited the footage into a video that allows electrical inspectors to get a better understanding of what PV is and how it should be installed. We aren't trying to cover every possible rule or condition in a video. We want to convey the idea that PV is a legitimate technology that should be part of an electrician's—and an electrical inspector's—area of expertise.

This video had a trial run at a meeting of the Rhode Island Electrical Inspectors' Association in January 2002. This Association holds regular meetings as a forum for electrical inspectors and master electricians from around the state. They learn from one another, share experiences, and keep up to date on developments in the electrical industry. We hope the video has helped break new ground for PV systems in Rhode Island, and spares the first-time PV system purchaser some of this burden. Download a sample digitized clip from the video at www.homepower.com.

In the midst of this project, one thing I realized is that many people in the "mainstream" world are either ignorant of RE's potential, or have some interest and knowledge, but need a little more information or confidence to start accepting and using the technology.

I believe that solar energy will become more popular when adding it to a home is no more involved than adding any other large appliance. This television program of my installation shows how this can be possible. I'm pleased to be using the art and technology I've mastered—television—to promote renewable energy, which is so important to all our futures.

Access

DJ Johnson, Spot Digital Video, 294 West Exchange St., Providence, RI 02903 • 401-453-6161
Fax: 401-421-6443 • spot@spotvid.com
www.spotvid.com

Erich Stephens, SolarWrights (division of RemodelWrights Corp.), 464 Maple Ave., Barrington, RI 02806 • 401-245-1550 • Fax: 401-245-3087
estephens@remodelwrights.com
www.remodelwrights.com

ASE Americas, 4 Suburban Park Dr., Billerica, MA 01821 • 800-977-0777 or 978-667-5900
Fax: 978-663-2868 • sales@asepv.com
www.asepv.com • PVs

Advanced Energy, 28 Riverview Mill, Box 262, Wilton, NH 03086 • 603-654-9322 • Fax: 603-654-9324
info@advancedenergy.com
www.advancedenergy.com • Inverter

Solar Cooking

And the Livin' Is Easy

Jennifer Stein Barker

The solar cooking assortment (left to right): Zomeworks SunFlash parabolic cooker, Sunspot, Sun Oven, Suntoys (in front), and Solar Chef (in back).

At the 1992 Solar Energy Expo and Rally (SEER) in Willits, California, I met a man with dreadlocks who was dancing around a cardboard box with a jar of boiling beans inside. Joseph Radabaugh willingly sold me the plans for this magic box, which I went home and made for about US$5 worth of materials. Boxes are free, and I already had a roll of aluminum foil, glue, and all the other materials, except the can of heat-tolerant black paint. Within a few days, I was cooking with the sun.

My homemade SunStar cooker did everything as well as any commercial solar cooker I've had since, except that it had a tendency to cartwheel across the lawn in a wind gust if I left it empty. (I put a rock in it to prop the pans on and hold heat, but it still wasn't heavy enough.) I baked cakes, casseroles, and breads outdoors all summer instead of gathering firewood for the woodstove and having to look for cool mornings to do my baking.

The next year, my partner Lance bought me a Sun Oven and I increased my solar cooking. It was not a more efficient cooker, just more convenient to use. In addition to eliminating the cartwheeling problem, it was not damaged by a sprinkle of rain, so I could leave it out more of the time. It was also easier to open and access the food.

In the following years, my collection grew to include a Sunspot, a Solar Chef, and a Suntoy cooker. The most recent addition is a donated Zomeworks parabolic cooker. I'm looking forward to learning how to fry with the sun this spring!

How Solar Cookers Work

The three basic types of cookers are single-reflector box cookers, multiple-reflector solar ovens, and parabolic cookers. My experiences are with the multiple-reflector style, which I think works best for baking at northern latitudes.

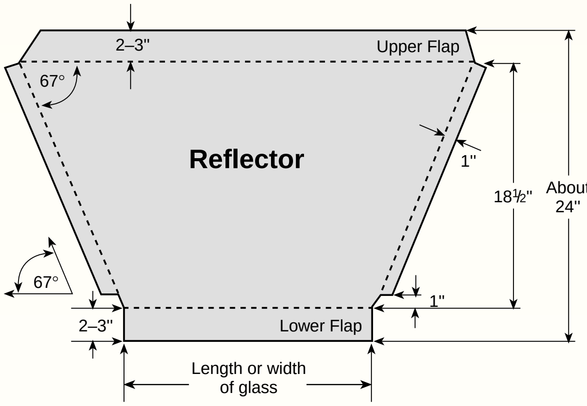
I have actually never used a single-reflector style cooker. It makes sense to me that the less sun you

Build a SunStar Solar Cooker

The SunStar solar cooker was designed to cost as little as possible and to be easily made by anyone, using commonly available materials. These instructions are adapted from the book Heaven's Flame, *by Joseph Radabaugh.*

For a medium-sized cooker, find two roughly square cardboard boxes. The inner box should be about 12 inches (30 cm) per side by 8 inches (20 cm) deep. The outer box should be 2 to 3 inches (5–8 cm) larger in all dimensions. Collect additional boxes for insulation and reflectors. Also needed are white glue, aluminum foil, flat black paint, glass, and string.

Pack layers of cardboard between the inner and outer boxes for insulation. Fold down all flaps between the boxes except the longest two on the outer box. Paint the inside of the inner box flat black. Make four reflectors based on the length and width of the glass as shown.



Fold the lower, side, and upper flaps on each reflector. Glue down the upper and lower flaps only. Lay each reflector flap-side down and cut foil to cover it. Coat the dull side of the foil with glue, and rub the foil onto the reflector from the center outwards.

Arrange the reflectors on the ground as they will fit on the oven box. Glue two diagonal sets of adjacent corner flaps together. Tie the remaining flaps together, using string through holes poked into the flaps. To hold the reflectors in place, make a slip-in piece that is attached to the bottom of the upper long reflector and pushed between the layers of insulation surrounding the inner box.

Use a dark baking tin as a rack to hold cooking vessels, or build your own rack out of wood or metal, painted black. Prop the cooker, both in front and back, with rocks to tilt it towards the sun.

Joseph Radabaugh, PO Box 111, Mt. Shasta, CA 96067 • SunStar solar cooker noncopyrighted, one-page plans. Enclose US$1 or more contribution and SASE

have, and the lower the angle, the more reflectors you need to concentrate the sun. I do find that the more reflector area there is on my cooker (in relation to the container volume and other efficiency factors), the hotter that cooker gets. Parabolic cookers focus the sun's heat intensely on a spot, allowing stovetop-like cooking. I'm just starting to play with a parabolic cooker, so I can't tell you much about them.

Solar cooking requires three basic components:

- A cooking vessel for food (preferably dark to absorb sunlight as heat, and often covered to keep heat and steam in with the food);
- An outer container to hold the heat next to the cooking vessel's surface; and
- Reflectors to concentrate the sun's heating power into the containers.

Many variations on these themes can be found. The outer container can be completely transparent or partially lined with black or silver. The solar window can

The solar cookers are part of an overall energy scheme at the Barkers' homestead.

Solar feast: risotto casserole, chocolate-mint ricotta mousse, crusty bread, and green salad.

be made of glass or plastic. When it comes to the reflectors, they come in all styles—from one flat reflector on one side, to four flat reflectors surrounding the cooking chamber, to many beveled ones, all the way to a complete, curved parabola. Efficiency depends on the performance of all aspects together. Sacrifice any one, and performance suffers.

My cookers will reach temperatures between 350 and 450°F (175–230°C) when empty. When food is placed in them, the temperature immediately drops due to the cold mass, but rises again as the food heats up and cooks. Any temperature above boiling will cook food, but baking requires hotter temperatures to get the rising food cooked before it falls. Food may cook a little slower when the ambient temperature is colder, but the intensity of the sun is far more important than the ambient temperature. Cooking in snow is possible because the snow reflects and intensifies the sun's rays, usually making up for the colder ambient air temperature.

Cooking Tips

To use a cooker, place your food in the cooking vessel, put the vessel in the outer container, close the outer container, and aim a transparent side of the outer container towards the sun. The reflectors will then be arranged to direct the sun's reflection through the transparent plane of the outer container onto the surface of the inner container. Sometimes (as in some parabolic cookers) there is no outer container. Then the reflectors will be arranged to permit the sun's reflection to directly strike the surface of the cooking vessel.

Two general types of dishes cook well in solar ovens—casseroles and loaves. Each type has its own particular cooking characteristics. Any recipe designed for a slow cooker will do very well in a solar oven.

Casseroles

Casserole recipes for solar cookery have more water in them to allow the pastas, grains, and legumes to cook. They can be put into a cold oven, and the whole thing can come to boiling temperature together. Once the contents come to a boil, cooking time will be the same as in a conventional oven. But it may take quite a while to get the whole mass up to boiling temperature.

If you are assured of a clear day, and your casserole doesn't require more than a half hour of boiling time, you can place it in the solar oven, turn it to where the sun will be at 3 PM, and go away. Dinner will be ready

Main Dish

Risotto

This is a baked rice dish in the Italian style. If you cannot get fresh oregano and lovage, follow the substitutions for Winter Risotto. Serves 4:

- 1 2/3 cups raw brown rice
- 2 Tbsp. lentils
- 1 1/2 cups chopped or ground tomatoes
- 2 2/3 cups stock or water
- 1 small onion, sliced thin
- 2 cloves garlic, minced
- 1 small turnip, coarsely grated
- 1/3 cup chopped fresh oregano
- 2 tsp. finely chopped fresh lovage leaf
- dash Tabasco
- 1/4 tsp. ground cumin
- 1 Tbsp. olive oil
- 1 Tbsp. tamari

Winter Risotto

For the fresh oregano and lovage substitute:

- 2 tsp. dried oregano, crushed
- 1/2 tsp. fennel seed, crushed or ground

Combine ingredients in a 2 quart or larger casserole. Stir to mix. Bake, covered, in sun oven until all liquid is absorbed. The rice and lentils should be tender (if not, add more liquid next time). When it is done, the herbs will be on the top. Stir everything together before serving. Serve with a crusty bread and green salad.

and warm at 5:30 PM. (Don't do this with meat or any other potentially dangerous food that spoils easily.) For longer cooking times, you must turn the solar oven at least every half hour or so to keep the contents boiling.

Breads & Cakes
Loaves, like breads and cakes, do not have as much moisture in them as a casserole. They will come up to temperature much more quickly. You must put them in a preheated solar oven because rising dough must be cooked, or it will fall again. Watch your preheating oven carefully, because an empty solar cooker may quickly get hot enough to smoke the paint off the inside.

It is the mass of food inside the cooker that controls the temperature. A rock placed to heat in the empty cooker will provide mass to help hold the heat whenever you open the door to put in food. For breads and cakes, preheat the cooker to 300 to 400°F (150–200°C). Being precise isn't necessary, because as soon as you put your loaf in, the temperature will fall to 300°F or less. Don't worry—raised or quick breads and cakes will still cook just fine.

Turn the cooker as frequently as you can to keep it facing into the sun. Cooking time will only be about 15 to 20 percent longer than in a conventional oven. When your bread or cake looks done, open the cooker and check it. If it isn't quite done, then 5 minutes more will usually do the job. Don't overload your oven with food that needs quick heat to rise. If your loaf or cake falls, you need to put less food in next time.

Winter is not an impediment to solar cooking. This pan of soup is steaming away in the sun of a 0° F winter-solstice day!

Dessert

Chocolate-Mint Ricotta Mousse

A velvety-smooth mousse with a secret!
Serves 6:

- 2 1/2 squares unsweetened chocolate
- 1/2 cup honey
- 1, 15 oz. container low-fat ricotta cheese
- 1/4 cup spearmint leaves, packed

Measure the honey in a heat-proof cup. Break up the chocolate squares and add them to the honey, pushing the chocolate down so it's covered. Heat honey and chocolate in a solar oven just until the chocolate melts.

Scrape the honey and chocolate into a blender. Add the ricotta cheese and mint leaves. Blend until liquid and smooth. You may have to stop the blender frequently and scrape down the sides, pushing the cheese down onto the blender blades.

When smooth, pour into a serving dish or individual cups. Chill for at least two hours before serving. Garnish with fresh mint leaves.

I have burned baked goods in my Solar Chef. This is possible because it has a wide "angle of acceptance" for the sun's rays. With the Sun Oven, if I neglect to check the food, I also neglect to turn the oven and the sun passes by its angle of acceptance, making it harder to burn food—but still possible. I have burned brownies, which cook very quickly.

More Hot Tips
Dark pans and casseroles absorb more heat and help food to cook more quickly. My favorite cookware for solar cookery is an amber glass Corning Ware covered casserole, because I can see what's happening in it. Dark graniteware works well, too. Always cover a casserole to keep as much steam in the dish as you can. A steamed up glass seems

Solar Cooker Comparison

Cooker	Cost (US$)	Characteristics	Uses	Advantages	Disadvantages
SunStar (Radabaugh design)	$5	Multiple reflector, homemade, cardboard	Baking, casseroles	Efficient heating, low cost	Can't leave out in rain, less convenient to open and close
Other home-made cookers	5–50	Purchased or found materials	Various	Low cost, fun, can be highly efficient	Have to construct, often heavier than commercial cookers
Suntoy	18	Multiple reflector, foil bubble pack	Boiling, baking, casseroles, meal-in-a-bag	Lightweight, portable	Longer cooking times, fairly small food volume
Sunspot	41	Multiple reflector	Mini loaves, meal-in-a-bag	Lightweight, portable	Longer cooking times, very small food volume
Sun Oven	275	Multiple reflector	Baking, casseroles	Efficient heating, easy to use	Moderate food volume
Solar Chef (No longer available)	425	Multiple reflector	Baking, casseroles	Highest efficiency, quickest cooking times	Won't hold a 9x13 inch baking pan, gets hot: must watch to avoid burning food
SunFlash (Zomeworks)	425	Parabolic	Boiling, frying	Can't fry in any other cooker type, high heat output	Small (or no) enclosed cooking chamber, blindingly bright reflectors

to transmit plenty of light, but it is harder to tell that your cooker is facing the sun perfectly if you can't see the shadows inside. When food is done, cover the cooker with its reflectors or a thick blanket to keep it warm until needed.

Cheese turns to leather quickly when baked in the sun. To keep your cheese tender and melting, try these techniques. Roll your pizza up, put it in a loaf pan, and then raise and bake it like a loaf of bread. Put sauce on top of the cheese. Or add the cheese a few minutes before your pizza or casserole is done, and continue cooking just till it melts and bubbles.

Use a dark graniteware teakettle or a widemouthed jar painted black to boil water in. Use tape to mask off a stripe when you paint the jar, so the contents can be viewed during cooking.

A thermometer often comes with a commercial cooker. If it does not, a regular oven thermometer works very well. I have successfully used a stovepipe thermometer, attached by its magnet to the side of a graniteware kettle, to let me know the temperature of the kettle's contents.

Safety & Care

Some things are, excuse the pun, glaringly obvious: these cookers are made to reflect a lot of light in order to create a lot of heat. Don't mess around. Protect yourself by avoiding the direct reflection, which can be blinding. Wear sunglasses. Use oven mitts or hotpads. If you have a parabolic cooker, turn the reflector away from the sun before removing a pan from the "burner."

Take good care of your cooker so it will continue to perform well for you. Even if your cooker is "waterproof" and you have no room to store it inside, it's a good idea to cover it when not in use. Waterspots and scratches diminish the effectiveness of the reflectors. If you wipe up spills and maintain the interior surface, your cooker will serve your needs for many times longer than a poorly maintained one.

Cooking Is Easy

Have a lot of things to cook in one day? Experience will show you when the earliest practical time occurs that the sun is high enough to get an oven hot in your area. At my house, that's around 8:45 AM in midsummer. If you have the next dish ready to go when one comes out of the oven, you can get several things baked in one day.

To get you started, here's an easy meal. Planning ahead is key, so before starting this, organize your day. Make dough for your favorite crusty bread first thing in the morning and set it to rise. Then make the mousse, and set it to chill for dessert. Bake the bread when it has risen, then take a few hours off. Come back early to midafternoon (the shorter the days, the earlier you must get your cooking done) and make the Risotto for dinner. Sounds like a long day, but the sun is doing most of the work for you!

Even as a hobby or novelty, solar cooking has a huge potential for saving energy and lowering your energy costs. Think about it—every time you turn the knob on that juice-sucking monster you call an electric stove, your use is immediately measured in kilowatt-hours.

And what if you live on a homestead or in a third-world country and burn organic matter (dung or wood from trees or shrubs) to cook every meal? You'd have to gather or buy every stick, and deal with an overheated house in warm weather. Compare that to just setting a reflector oven out to gather the sun's rays whenever the weather cooperates. You'll soon be singing: "Solar cookinnngg... and the livin' is easy!"

Access

Jennifer Stein Barker, 15013 Geary Creek Rd., Canyon City, OR 97820 • 541-542-2525
jbarker@highdesertnet.com
www.highdesertnet.com/morninghill • *The Morning Hill Cookbook* (US$11.95 ppd.) and *The Morning Hill Solar Cookery Book* (US$14.95 ppd)

Heaven's Flame: A Guidebook to Solar Cookers by Joseph Radabaugh. 1998, ISBN 0962958824, *Home Power* Publishing, PO Box 520, Ashland, OR 97520
800-707-6585 or 541-512-0201 • Fax: 541-512-0343
hp@homepower.com • www.homepower.com
Presently out of print

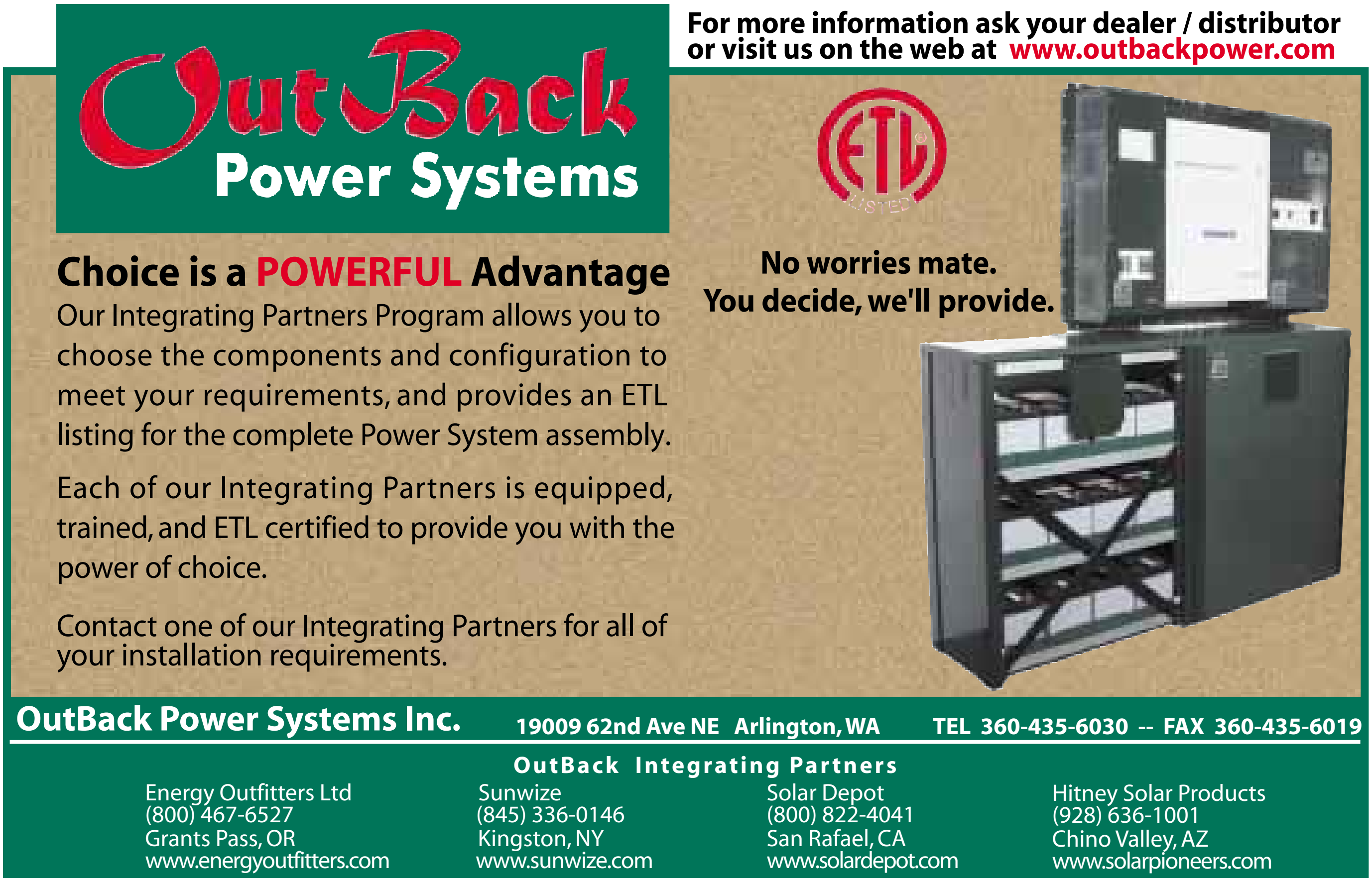
Cooking with the Sun by Dan & Beth Halacy. 1992, ISBN 0962906921, US$9.95 plus $2 shipping, Morning Sun Press, Jack Howell, PO Box 413, Lafayette, CA 95459 • 925-932-1383 • jdhowell@ix.netcom.com
http://home.ix.netcom.com/~jdhowell • Books and solar cooker plans

Sun Ovens International, Inc., 39W835 Midan Dr., Elburn, IL 60119 • 800-408-7919 • Fax: 630-208-7386
sunovens@execpc.com • www.sunoven.com • Global Sun Oven

Suntoys, 14837 206th Ave. SE, Renton, WA 98059
206-230-5286 • Fax: 206-219-1100
davidpiper@usa.net • Suntoy cookers

Scott Resources/Hubbard Scientific, PO Box 2121, Fort Collins, CO 80522 • 800-289-9299 or 970-484-7445
Fax: 970-484-1198 • ssavig@amep.com
www.hubbardscientific.com • Sunspot Solar Oven

Zomeworks, solar cooker contact: Randy Carlson, 1011 Sawmill Rd. NW , Albuquerque, NM 87125
800-279-6342 or 505-242-5354• Fax: 505-243-5187
zomework@zomeworks.com • www.zomeworks.com
SunFlash parabolic solar cookers


For more information ask your dealer / distributor
or visit us on the web at www.outbackpower.com
OutBack
Power Systems
Choice is a POWERFUL Advantage
Our Integrating Partners Program allows you to choose the components and configuration to meet your requirements, and provides an ETL listing for the complete Power System assembly.
Each of our Integrating Partners is equipped, trained, and ETL certified to provide you with the power of choice.
Contact one of our Integrating Partners for all of your installation requirements.
No worries mate.
You decide, we'll provide.
OutBack Power Systems Inc.
19009 62nd Ave NE Arlington, WA
TEL 360-435-6030 -- FAX 360-435-6019
OutBack Integrating Partners
Energy Outfitters Ltd
(800) 467-6527
Grants Pass, OR
www.energyoutfitters.com
Sunwize
(845) 336-0146
Kingston, NY
www.sunwize.com
Solar Depot
(800) 822-4041
San Rafael, CA
www.solardepot.com
Hitney Solar Products
(928) 636-1001
Chino Valley, AZ
www.solarpioneers.com


E-mail: hp@MrSolar.com
877-226-5073
MrSolar.Com
VOTED BEST SOLAR WEBSITE
By the people who count, our customers.
$ Best Web Prices $
Online Convenience
In Person Service
-System Design
-Huge Inventory
-Experienced Staff

Solar Powered Wireless Phone System

Rob Savoye

Two Uni-Solar US-64 PV modules provide power to the landline end of Rob Savoye's 4 watt, UHF radiotelephone.

Because the nearest phone lines don't come anywhere near my house, I wound up installing a Telemobile Ptel wireless phone for my off-grid, geodesic domes. This is not a cordless phone, but a telecommunications grade, long-range, wireless system. It is a 4 watt, UHF-based system with a line of sight range of about 25 miles (40 km).

The local phone company gave me some huge number for a quote to run lines to my house. At the same time, I didn't really feel like digging up the road to run a very expensive phone line. Good satellite technology is just around the corner, and there are good wireless solutions available now.

The home end of the radiotelephone system is wired directly into my 12 VDC household system. The full house electrical energy system has 480 watts of photovoltaics, and 340 watts of wind power. These charge a bank of twelve Trojan L-16s. My domes are wired for 24 VDC to power lights and heavy loads, 12 VDC for the phone, and 120 VAC for standard AC appliances.

I worked out the best location for the landline end using a GPS, mapping software, and two handheld ham radios. Once I identified the best four potential sites, I chose the one I could most easily negotiate access to.

The landline end is powered by a stand-alone PV system. This system is housed in a PortaPak plastic container. I lined the box with closed cell foam all around, and a 2 inch (5 cm) thick piece of Styrofoam for the base. I then cut holes for the phone line input, the antenna coax cable, and the power cable from the solar-electric panel. The box protects the system from the weather, and has good handles for the locks. I chained the box through both the handles to a tree. While this is a remote location, I still wanted to be careful to prevent easy vandalism.

The landline end is literally at the termination point of the phone lines in this area. Due to the inability to negotiate access with the local phone company, I got permission to use private property. The bills come directly to me. The system is in a meadow, about 500 feet (152 m) from the property owners' house, and by their request, is totally out of sight from anywhere in their yard.

Portable & Permanent Power Systems

I initially started by using a portable power system I already had, while I ordered the parts for a permanent system. My portable system is powered by a Uni-Solar

amorphous 64 watt panel. I started out using two panels, but found that only one was necessary. Two, 235 amp-hour (6 VDC) Trojan T-125 deep-cycle batteries, and a 24 amp Lyncom charge controller complete the system.

The system was designed in a seat of the pants way, but worked well for its temporary use for the phone. I used the two T-125s because at 66 pounds (30 kg) each, I can cart them to wherever I need them.

The permanent system is a little different from the portable one. It has a smaller charge controller, a Solsum 5.0, which only handles 5 amps. I also have a 12 volt Deka 280 AH gel-cell battery. This battery will deal much better with the cold weather (-40°F; -40°C) that we get around here at 8,700 feet (2,650 m) elevation in the Colorado Rockies.

Replacing the batteries turned out to be interesting. The old batteries were heavy, but still hand cartable by one person. The new gel cell weighs more, around 135 pounds (61 kg). I wound up doing the replacement as winter was kicking in. I used a sled to transport the batteries, since there wasn't any vehicle access to where the landline terminated, and there was plenty of snow.

This system was much more "designed" than the portable one. I used a spreadsheet to size the power system and specify the correct wire gauge to keep the voltage drop between the PVs and the battery under two percent. These free spreadsheets are on my Web site at www.senecass.com/software.html.

Rob's son, Abel uses a Solar Pathfinder to pick the best location for the PV panels.

Phone System

The phone system is two dedicated UHF transceivers, each with a Yagi directional antenna. This system is FCC approved, and is built specifically for wireless telephones. One transceiver is wired into the landline, and the other is wired into the phone lines at the domes. At that point, it works like a regular phone, with a dial tone, etc.

A plastic tub protects the 280 amp-hour Deka gel-cell battery, Solsum 5 amp charge controller, and Telemobile Ptel radiotelephone.

It uses a "command and control" channel at about 3.8 GHz, and the main frequency is 452.462. Because it's full duplex, it uses two adjacent UHF frequencies for transmission.

I have a much more detailed document on the trials and tribulations of installing and maintaining this system at www.senecass.com /rob/domes/phone.

How It Has Worked Out

So far, it has worked pretty well. The main problem is that my antenna coax, at the house end, runs too close to the Heart HF-24-2500X inverter power feed, which causes some 60 Hz hum in the phone line.

We've also discovered a problem with heavy loads. If I run the large 1,400 watt miter saw during the day

when there is plenty of excess energy, things work OK, although the saw makes a noise on the phone line. But if I try to do this at night, when running 100 percent off the batteries, running the saw will disconnect the call. This hasn't been too inconvenient—I just have to make sure I don't saw anything when anyone is on the phone. The 120 VAC booster pump for my domestic water also creates a lot of noise on the phone line. So we've found that it's not good to use water when somebody is on the phone.

I've tried to get my computer modem to successfully connect over the wireless phone. I've discovered that if I turn off my inverter, I can get my computer to establish a decent PPP connection. It's about the same baud rate as a cellphone, but at least it's inside...

This is the only phone in my domes, because the telephone company lines terminate almost a mile from my property. Cell phones barely work around here, so the wireless phone is our only communication link from the domes, which we live in full time. We're used to using solar electricity at our off-grid home. So setting up a PV system for the radio phone was a natural.

Access

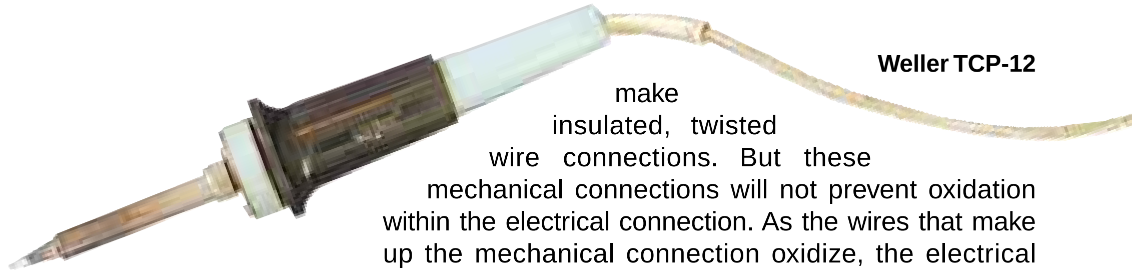
Rob Savoye, Seneca Software & Solar, 60 Bigbee High Rd., Ward, CO 80481 • 303-258-0506
rob@senecass.com • www.senecass.com

Telemobile, Inc., 19840 Hamilton Ave., Torrance, CA 90502 • 310-538-5100 • Fax: 310-532-8526
telemobile@telemobile.com • www.telemobile.com
Phone system

Rocky Mountain Solar, Inc., Box 220-171, Woodland Park, CO 80866 • 719-687-1002 • Fax: 719-686-9760
rms@dim.com • www.rockymtsolar.com • PV system components

How to Solder—The Basics

Richard Perez



Weller TCP-12

Soldering ensures permanent, low loss, electrical connections. A soldered electrical connection is not difficult to make. It only requires a little practice and the right tools.

If you're making your own electricity, your system's wiring and its maintenance are critical. Without good electrical connections, even the finest system will perform poorly or not at all. Here's what you need to know to make effective soldered connections for your system.

Electrical wiring is made of copper and aluminum because both metals have low resistance to electron flow (electric current). The major problem with mechanical connections is the formation of oxides on the copper or aluminum. These oxides are poor conductors of electricity, and they cause the resistance of a mechanical connection to increase.

The pure copper or aluminum on the surface of the wire gradually changes to copper oxide or aluminum oxide by chemical reaction with the oxygen in the air and water. It only takes one weak or bad link in the electrical chain to render the entire circuit in-operative.

Why Solder?

Mechanical connections are made by twisting the bare wires together or by compressing a wire into a connector or terminal. Wire nuts can be used to make insulated, twisted wire connections. But these mechanical connections will not prevent oxidation within the electrical connection. As the wires that make up the mechanical connection oxidize, the electrical resistance of the connection increases. This results in a voltage loss across the connection.

Weller D550

A well-made soldered connection will have lower resistance than a new mechanical connection, and will not oxidize with time. Years down the road, the soldered connection will have many times less resistance than the oxidized mechanical connection.

In 120 volt wiring, the voltage loss due to oxidized mechanical connections is negligible because the input voltage is so high—120 VAC—so the current is low. Here, mechanical connections are standard and perfectly acceptable. In 12 volt systems, however, the voltage loss in poor connections can make a system fail.

The table opposite shows voltage drop and power losses for a hypothetical 120 watt load in a circuit with 0.2 ohm resistance over a variety of voltages. Poor connections really hurt in low voltage systems!

Soldering a connection ensures that it will not oxidize and increase in electrical resistance. Do it right once, and it will work for a long, long time. But you must do it right. A bad soldered connection can have more resistance than a mechanical connection.

When to Solder

Any low voltage electrical connection involving copper wire, where oxidation or corrosion is a potential problem, is a candidate for soldering. Obviously, there will be some purely mechanical con-nections in any system. It's not prudent or possible to solder to battery terminals, inverters, and controls—here mechanical connections are appropriate. Aluminum wires can't be soldered.

Here is a list of appropriate places for soldered connections.

- Any connection that lives outside in the weather, especially connections between wire and ring or spade connectors.

Voltage Drop & Wattage Loss in a 0.2 Ω Circuit at 120 Watts

Voltage	*Current Amps*	*Voltage Loss*	*Voltage Loss %*	*Voltage Through*	*Wattage Loss*	*Wattage Loss %*
12	10.0	2.0	16.7%	10.0	20.0	16.7%
24	5.0	1.0	4.2%	23.0	5.0	4.2%
36	3.3	0.7	1.9%	35.3	2.2	1.9%
48	2.5	0.5	1.0%	47.5	1.3	1.0%
120	1.0	0.2	0.2%	119.8	0.2	0.2%
240	0.5	0.1	0.0%	239.9	0.1	0.0%

- Low voltage distribution wiring where it connects to the main DC bus.
- Any low voltage appliance's power wires where the appliance is hard-wired and thereby doesn't need a plug (a ceiling light, for example).
- Connectors on all battery or cell cables. The corrosive environment surrounding batteries will ruin mechanical connections very quickly. The connectors used to bolt to the cells must be soldered to their cables. See next issue for a detailed article about how to build these cables.
- Any place you want to save money. Not only is soldering more permanent than mechanical connections, it's far less expensive in the long run. Connectors, wire nuts, crimpers, and the like cost at every connection. A soldered joint is much more durable, and outlasts nonsoldered connections.

The Tools

The tools needed to solder are few: a source of heat (soldering iron, gun, or torch), solder, and flux. The soldering iron should fit the job at hand. Just as you can't remove a 1 inch nut with a 1/2 inch wrench, you can't solder big cables with a small iron.

Most soldering irons and guns are electrically powered, and come in sizes from 4 watts to over 300 watts. They are available with input voltages of 12 or 120 volts. Some are butane or propane powered. If you are serious about soldering, you will need several different sizes of irons, just as you need different sizes of wrenches and screwdrivers.

Low wattage irons are designed for use on electronic printed circuit boards or small sized house wires (up to #14; 2 mm^2). They put out between 4 and 25 watts of heat to a tip that does the soldering. Pictured above left is the Weller TCP-12, which draws 2.3 amperes at 12 VDC.

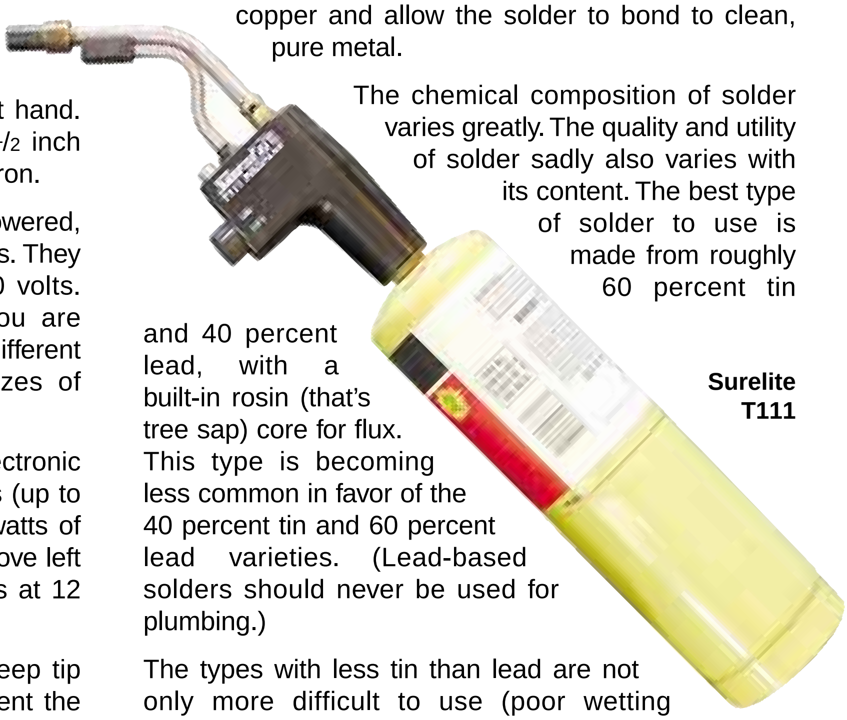
The TCP-12 is thermostatically controlled to keep tip temperature constant (700°F; 371°C), and prevent the iron from burning up its tip when not in active use. The TCP-12 costs about US$50, and is professional quality. We've used the one pictured here for over fifteen years in heavy service. Tips come in all sizes and are easily replaced. This type of soldering iron is also available in 120 VAC models.

Medium wattage irons are usually 120 VAC, and draw between 45 and 260 watts. The large Weller soldering gun (Model D550) is our favorite and runs on inverter produced electricity very well. It produces enough heat to quickly solder several #10 (5 mm^2) copper wires. Soldering ring connectors and tinning wire up to #8 (8 mm^2) is easily accomplished with the Weller gun. It has two heat levels—200 and 260 watts, but we run it wide open almost all the time. This soldering gun and others are available at hardware stores for under US$40.

For heavy duty soldering, it's hard to beat a propane torch. These are available from hardware and discount stores for less than US$30. See next issue for an article on torch type soldering. Care must be taken in torch soldering not to burn the flux with the open flame.

What Kind of Solder to Use

Soldering is the process of bonding bits of copper together by flowing a molten metal around the copper. Solders are mostly mixtures of tin and lead with flux added. Flux is a chemical compound that, when hot, will chemically strip off the oxidized surface layer of copper and allow the solder to bond to clean, pure metal.



Surelite T111

The chemical composition of solder varies greatly. The quality and utility of solder sadly also varies with its content. The best type of solder to use is made from roughly 60 percent tin and 40 percent lead, with a built-in rosin (that's tree sap) core for flux. This type is becoming less common in favor of the 40 percent tin and 60 percent lead varieties. (Lead-based solders should never be used for plumbing.)

The types with less tin than lead are not only more difficult to use (poor wetting characteristics), but make a joint with less mechanical strength. Wetting means that the solder got

hot enough to flow evenly over and through the work. Evidence of this is the concave solder surface where the solder joins the boundaries of the work.

Under no circumstances should you use a solder with a tin content less than 40 percent. Don't use solder with acid core flux—it's for plumbing. Rosin core fluxes are noncorrosive over time, and should be used on all electrical work, regardless of solder composition.

The Ritual of Solder

Soldering is a skill that has ten basic steps. If you follow these steps, you will get a permanent, good connection every time.

1. Strip about 1 inch (25 mm) of insulation from the ends of the wires to be joined.

For delicate electronics work, use a lower wattage iron and thin solder.

2. Solder only clean copper. Soldering will not work on corroded, greasy, or dirty copper. Sand or polish all the parts of the connection bright before making a mechanical connection.
3. Make a tight mechanical connection before soldering. Soldering is not a substitute for mechanical connection: it merely makes it permanent by sealing out oxidation. Twist wires together firmly, or crimp wire into a connector before soldering.
4. Use a soldering iron sized to fit the job. Use low wattage irons for small connections with small thermal mass, and high wattage irons for big jobs with large mass.
5. Heat up the iron, clean it (wipe with cloth or paper towel), and re-tin its tip with fresh solder just before making a solder joint. It is impossible to effectively transfer heat from a funky soldering iron tip.
6. Place the hot iron on the work and melt a small amount of solder on the tip where it meets the work. This small puddle of molten solder between the tip and the work greatly increases thermal transfer.
7. Place the solder against the work, *not* against the soldering iron's tip. This melts the solder on the work where its flux will deoxidize the copper. Melting the solder against the tip causes the flux to eat up the tip instead of the copper oxide on the work. This makes a poor soldered joint and wears out tips rapidly.
8. Flow only as much solder into the joint as it will easily accept.

Larger work needs a larger iron. Remember to heat the work, not the solder.

9. The finished joint should be bright and shiny with concave solder surfaces—no convex blobs of solder.
10. Insulate the soldered joint with either heat shrink tubing or electrical tape.

Is It a Good Soldered Connection?

If the connection is a good one, the solder will be bright and shiny. All solder surfaces will be concave (valleys) indicating good wetting of the solder. This means that enough heat was used to make the joint, and that all parts were hot enough to suck up a good, yet thin, coat of the solder.

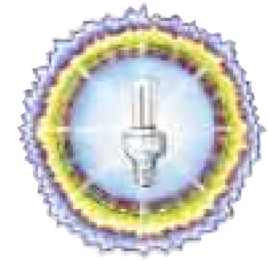
Connections made with too little heat will show convex solder surfaces (hills or blobs), indicating that the solder didn't get hot enough to flow easily. Solder joints made with too much heat have a grey, dull, and granular appearance.

Soldering is a skill. It takes practice. Work with scraps until you can get good joints. Underheat the work and see what happens. Overheat joints until you can see the effects of too much heat. These skills can be learned by anyone willing to pay attention for a single afternoon. Practice makes perfect.

Access

Richard Perez, *Home Power,* PO Box 520, Ashland, OR 97520 • 530-475-3179 • Fax: 530-475-0836
richard.perez@homepower.com
www.homepower.com

Home Power's Business



"The man who on his trade relies, Must either bust or advertise."
Sir Thomas Lipton — 1870

Display Advertising

Advertising Rates per Consecutive Insertion

	Single Insertion	*Three Insertions*	*Six Insertions*	*Ad Area sq. in.*
Full Page	$1,500	$1,350	$1,275	64.1
Half Page	$840	$756	$714	32.1
Third Page	$600	$540	$510	21.4
Quarter Page	$471	$424	$401	16.0
Sixth Page	$334	$300	$284	10.7
Eighth Page	$268	$241	$227	8.0
Twelfth Page	$188	$169	$159	5.3

Four process color (CMYK) in any sized advertisement is a flat rate of $185 per insertion. For inserts, and current subscriber/circulation demographics, please call us.

Home Power is published bi-monthly. The ad deadline for the June / July 2002 issue (*HP89*) is April 1, 2002. Call 541-512-0201 for further details.

First Class *Home Power* Subscription

Get 6 issues of *Home Power* magazine via First Class U.S. Domestic Mail for $43. All First Class issues are shipped in an envelope. We start your subscription immediately with the current issue.

Second Class *Home Power* Subscription

Get 6 issues *of Home Power* via Second Class U.S. Domestic Mail for $22.50. Second Class can be forwarded for one issue (two months), so let us know immediately if you move! Please allow up to ten weeks for your first copy to arrive.

MicroAds

MicroAd rates are 15¢ per character. Characters include numbers, spaces, and punctuation. $20 minimum per insertion (includes both print and web). Send a check with your ad. We do not bill MicroAds.

International *Home Power* Subscriptions

Due to the high cost of international mailing, we charge more for *Home Power* international subscriptions.

1 Year (6 issues) International Rates:

All payments in U.S. currency ONLY!

Canada:	Air — $43	Surface — $30
Mexico:	Air — $46	Surface — $30
Western Hemisphere:	Air — $48	Surface — $30
Europe:	Air — $64	Surface — $30
Asia and Africa:	Air — $77	Surface — $30
Pacific Rim:	Air — $77	Surface — $30

Surface shipment may take up to three months. All international issues are shipped in mailing envelopes. International subs are best paid for by either VISA, MasterCard, or funds from a U.S. bank.

International orders: Call: 541-512-0201
Fax: 541-512-0343

Back Issues of *Home Power* Magazine

Back issues through #20 are $6.25 each while they last. Back issues of #21–45 are $7.75 each. Back issues #46–84 are $8.75 each. Back issues #85 to present are $9.95 each. (Sorry, no more issues #1–12, 14, 15, 35, 36, 38, 40, 41, 59–61, 63–67, 79, 81, & 82.) Back issues are shipped First Class mail to U.S., Air to International. See the listing under Ad Index on the last page for details and current *Home Power* back issue specials.

Issues #1–42, 43–60, 61–70, 71–76, & 77–82 are on CD-ROMs for $29 each (Shipping: $2 in US; Canada $3; International $4).

Home Power Magazine for Resale

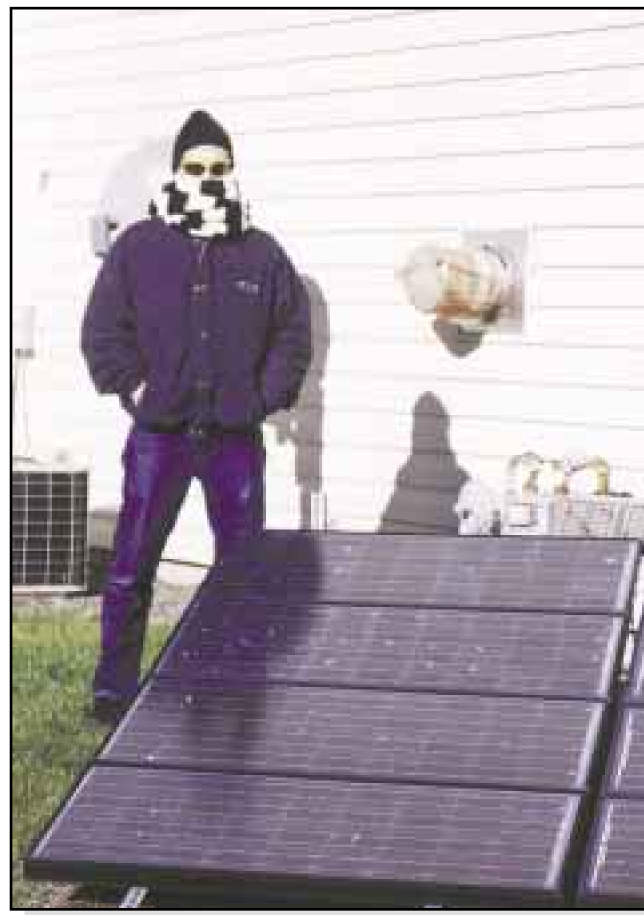
Quantities of *Home Power* magazine are available for resale by distributors, newsstands, bookstores, energy businesses, and others. Please call, email, or write for rates and shipment specifics.

ACCESS: Home Power, PO Box 520, Ashland, OR 97520 USA
Subscriptions and Back Issues: 800-707-6585 or 541-512-0201
Advertising: 541-512-0201 • Editorial: hp@homepower.com • www.homepower.com

THE UPS, DOWNS, AND UPS OF MICROSINE INVERTERS

GUERRILLA SOLAR: The unauthorized placement of renewable energy on a utility grid. PROFILE: 0019

DATE: February 2002
LOCATION: Northern Hemisphere
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 240 watts of PV
PERCENT OF ANNUAL LOAD: 7%
TIME IN SERVICE: 26 months



Two years ago, I purchased two MicroSine inverters and hoped to put some of my own solar generated energy on the grid. Each inverter was powered by two Solarex MSX60 panels wired in series.

The Ups

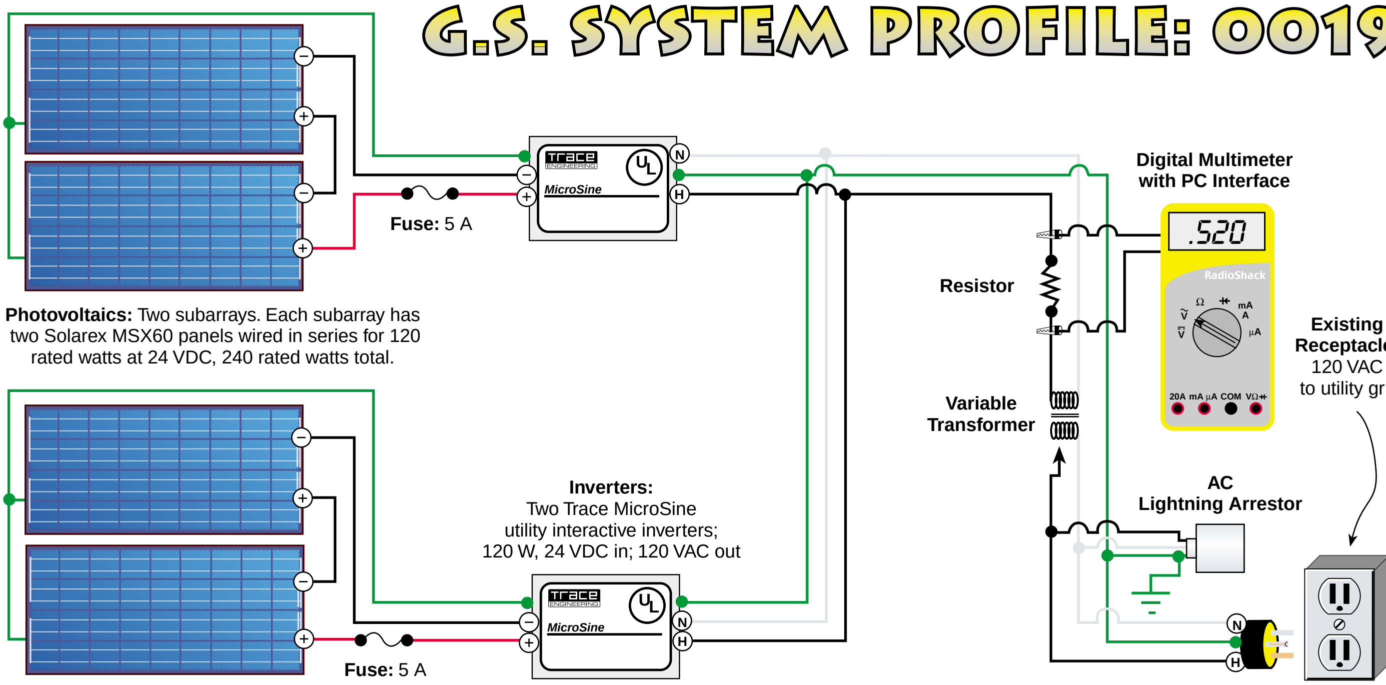
Installation was easy—the inverters were mounted on the back of the solar panels with the supplied hardware. The four solar panels were added to eight panels that make up my existing, stand-alone (nonutility intertied) solar-electric system.

I was happy to see the utility meter spin backwards (slowly) as soon as the inverters were plugged into the grid. The PVs and the MicroSines overcame the phantom loads (about 20 watts), and the always-on radon mitigation system (about 60 watts) in our house.

Everything seemed fine. But it was impossible to monitor the performance of these inverters, unless they were connected to the optional (and expensive) inverter communications adapter. I'm used to determining at a glance how well my stand-alone, solar-electric system is performing. I simply look at the scanning display of the E-Meter battery monitor. I wanted something similar to monitor the output of the MicroSine inverters, without an interface and a monitoring computer.

Clamp-on AC current meters or in-line AC utility meters can be used to monitor output easily. I had neither of these devices at my disposal. I finally decided to connect a small (0.36 ohm) resistor in series with the AC hot line. I then measured the voltage drop across this resistor with a simple AC voltmeter to measure and then compute the instantaneous power these inverters were producing.

G.S. System Profile: 0019



The Downs

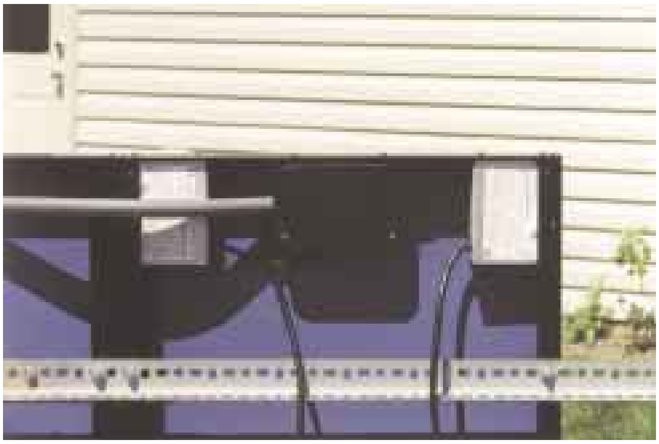
Shortly after installing the monitoring system, I noticed that sometimes, even in full sunshine, the inverters were not working at all, or only one inverter was working! Something was terribly wrong.

After additional measurements, I discovered that living close to a utility distribution system has its disadvantages. The measured AC voltage at receptacles in our house was typically 126 VAC, sometimes as high as 128 VAC, and usually never below 125 VAC, compared to 120 VAC at my workplace, 7 km (4.4 mi) away.

This grid voltage was awfully close to the inverter's high voltage safety shutdown level (127 VAC). This was probably the cause for the inverters' dropout behavior during the day. They would sense this high voltage, and shut down. As the grid voltage varied slightly during the day, sometimes voltage would be low enough for at least one inverter (and sometimes both) to consider the voltage within the "safe" zone. They would turn on again, and work until the grid voltage would rise outside these safe limits. Then they would turn off again.

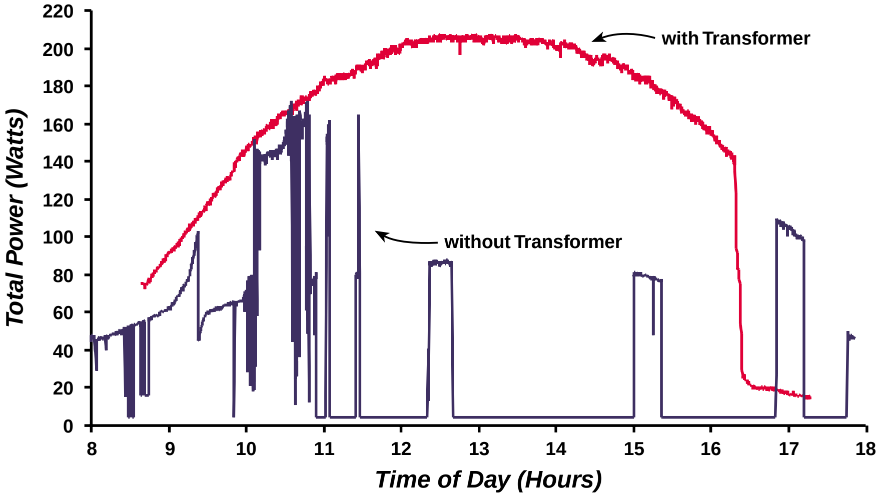
Adjusting or modifying the inverters was not an option, without buying the communications adapter. I needed a method to lower the AC grid voltage so that both of my inverters would still consider it within their preset voltage limits. Luckily, this is simply done with a variable transformer connected between the inverter output and the grid. It's safe, although most likely not code

Both MicroSine inverters connected to the back of one of four Solarex MSX60 solar panels.



The four guerrilla solar-electric panels are located on the left side of the array. The other eight panels power a small, stand-alone battery/inverter system.

MicroSine Output



compliant. A suitable transformer for my system is the Staco 221-B (330 W, 120 V) variable transformer, available from Newark.

By setting this transformer to 92 percent of output, my 126 VAC grid voltage is transformed down to 116 VAC for the inverters. This is halfway between the MicroSine's 104 and 127 VAC voltage limits. The MicroSines like this voltage, and run at about 116 VAC. The transformer steps this voltage up to 126 VAC to safely put my solar electricity on the grid. All inverter safety shutoff features are preserved this way, but are adjusted to my unusually high grid voltage.

And the Ups

The variable transformer connected between the output of the inverters and the grid worked well. I estimate that the variable transformer has a conversion efficiency of about 95 percent. My MicroSine system is now placing clean energy on the grid. During a nice, sunny, cloudless summer day, the two MicroSines typically produce approximately 1.3 KWH of energy, until the shadow of my neighbor's house falls on the solar panels about 4 PM. On partially cloudy days, my system produces about 1 KWH of energy.

My total system cost is a bit on the high side, but everyone has to start somewhere! If I were to purchase and build a utility intertie system for my house today, I would probably not purchase the MicroSines again. Their cost to output ratio is high (US$2.50 per watt) compared to newer and now available utility intertie inverters (less than US$0.80 per watt).

Clean & Easy Energy

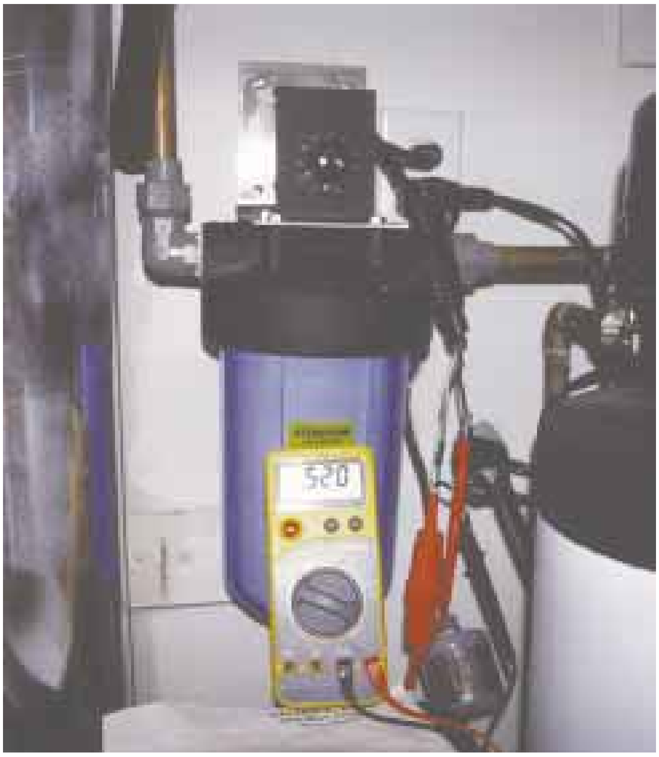
The MicroSine inverters can put clean energy on the grid easily and without hassle. But you should verify their operation at least once every three months by:

- Connecting them to a PC via their computer interface;
- Listening to them (they hum when working);
- Turning off all of your home loads, and verifying that the utility meter is spinning backwards;
- Measuring the array voltage at their input: if it's close to 40 VDC, the inverter is not working; if it's between 28 VDC and 32 VDC, the inverter is working; or
- Using a clamp-on ammeter, or the homebrew setup described in this article.

As with all systems, care and maintenance allows them to work properly for a long time. I find it fascinating to be able to produce my own electricity using energy from the sun. It's even more satisfying to put that electrical energy on the grid!

We can easily and safely consume energy from the grid by plugging in loads and appliances, and have that use recorded on our monthly electricity bill. We should be able to put energy back just as easily and safely, without the hassle of additional paperwork, rules, and

Transformer, measurement resistor (wire spool), AC lightning arrestor, and data logging multimeter.



GS 0019 System Cost

Item	*Cost (US$)*
4 Solarex MSX60 solar panels	$1,129
2 Trace MicroSine inverters	517
Staco 221-B variable transformer	70
Mounting hardware, cable, fuses	55
Delta LA 302-R lightning arrestor	35
Total	$1,806

regulations. My utility-intertied MicroSine system allows me to do just that. Happy clean energy production to all!

Access

Solar Guerrilla 0019 • Somewhere in the Northern Hemisphere

Sun Electronics International, Inc., 511 NE 15 St., Miami, FL 33132 • 305-536-9917 • Fax: 305-371-2353 info@sunelec.com • www.sunelec.com • Solarex MSX60 PVs

ETA Engineering, Inc., 2010 E. University Dr. Suite #20, Tempe, AZ 85281 • 877-964-4188 or 480-966-1380 Fax: 480-966-1516 • energy@etaengineering.com www.etaengineering.com • MicroSine MS100 inverters

Newark Electronics, 4801 N. Ravenswood, Chicago, IL 60640 • 800-4-NEWARK or 773-784-5100 Fax: 800-718-1998 or 773-907-5339 webmaster@newark.com • www.newark.com Variable transformer Staco 221-B

Mr Solar.com, PO Box 70060, Baltimore, MD 21237 877-226-5073 or 410-391-2000 • Fax: 410-686-6221 sales@mrsolar.com • www.mrsolar.com • Lightning arrestor, LA 302-R

Radio Shack, 100 Throckmorton St., Fort Worth, TX 76102 • 800-843-7422 or 817-415-3011 Fax: 817-415-3240 • support@tandy.com www.radioshack.com • Datalogging Multimeter RS 22-805

Guerrilla Solar Defined

Energy is freely and democratically provided by Nature. This century's monopolization of energy by utilities both public and private threatens the health of our environment. Solar guerrillas believe that clean renewable energy should be welcomed by utilities. But utilities and governments continue to put up unreasonable barriers to interconnection, pushing common citizens to solar civil disobedience.

Guerrilla systems do not endanger utility line workers (see *HP71*, page 58). They share clean, renewable energy with others on the utility grid, and reduce the need for polluting generation plants. When interconnection for small-scale renewables becomes fair, simple, and easily accessible to all, there will be no more need for guerrilla action.


SunEarth Inc.
Quality Solar Energy Products
THINK THERMAL-
THINK SUNEARTH
SunSiphon Thermosiphon System
www.sunearthinc.com
SunEarth, Inc.
4315 Santa Ana Street, Ontario, California 91761
(909) 605-5610, FAX (909) 605-5613
Distributor inquiries welcome.


SUN FROST
We've reduced
our energy use
even further!
Need a High Efficiency Refrigerator
for a Harsh Climate?
SUN FROST
P.O. Box 1101, Arcata, CA 95518-1101
Phone: 707-822-9095 • Fax: 707-822-6213 • www.sunfrost.com


INTRODUCING...
The NEW ProStar Solar Controller
• 15 or 30 amp
• 12/24 or 48 volt
• negative or positive ground
PROSTAR
a revolution in 1995 & again in 2001
all NEW technology providing exciting NEW features!
MORNINGSTAR corporation
1098 Washington Crossing Rd., Washington Crossing, PA 18977 USA
Phone: 215-321-4457 • Fax: 215-321-4458 • www.morningstarcorp.com


Maui Solar Energy Software Corporation
Maui Solar Energy
Software Corporation
www.mauisolarsoftware.com
PV-DesignPro v5.0 $149.00
•Included on Solar Design Studio CD
•Professional level PV/Wind design/simulation program
•Portions developed under contract to Sandia National Labs
•Sold worldwide since 1998
•Includes 4 hours of audio tutorial on CD
HP-79 - "Besides being a very good design tool for the professional, DesignPro is also a great learning tool." D. Loweburg
Standalone/Grid-tied/
Water Pumping
I/V Curve Tracer
239 U.S. Climates
Over 2,000 Global
Climates
TraceTools v1.0 $99.00
•Control/Monitoring/Data-logging for Trace SW Series Inverters
•Dialup Access to your remote system; view meters and set values
•Web charts and status e-mails
•Requires SWCA and Com Port
910 Haiku Road #113, Box 1101, Haiku, HI 96708
808-876-1859

Things That Work!

Tested by Home Power

Direct Power and Water's Series 120-6, Top-of-Pole Mount

Joe Schwartz

If site conditions permit, top-of-pole mounts are the mounting system preferred by many PV installers. Direct Power and Water (DP&W) of Albuquerque, New Mexico is one of the leading manufacturers of high quality, top-of-pole mounts. DP&W's mounts make for a quick, mechanically secure, and easily adjustable installation of your PVs.

A big advantage of top-of-pole mounts is that they keep the PV installer off the roof. This is a good thing for several reasons. Steep roofs can be dangerous to work on, not to mention difficult, slow, and hot. And even careful installers can cause unavoidable wear and tear to asphalt or composition roofs during PV installation.

Top-of-pole mounts eliminate the roof work. And since they allow much better air circulation, they also keep your PVs at lower operating temperatures compared to roof mounts. Lower module temperatures result in a significant increase in PV output.

DP&W Top-of-Pole Mount

The DP&W top-of-pole mount we evaluated is a series 120-6 mount, model DP-TPM8-SR100. It holds eight Siemens, 100 watt modules. DP&W makes top-of-pole mounts for all makes and models of PVs. Their smallest top-of-pole mount holds up to 15 square feet (1.4 m^2) of PV. Their largest holds up to 120 square feet (11 m^2) of PV. The retail price of the mount we tested is US$685.

Direct Power and Water's Series 120-6 top-of-pole mount can accommodate up to 120 square feet of PV.

The rack shown in the photos was installed by Bob-O Schultze of Electron Connection in northern California in the spring of 2001. I've installed close to a dozen DP&W top-of-pole mounts with Bob-O over the years. (He probably has twice that many out there.) We've experienced zero problems with these mounts in the field.

Design Features

DP&W's top-of-pole mounts are well packed for shipping, and standard mounts can be shipped via UPS. The assembly instructions provided with the mount are straightforward, and provide all the information necessary for assembling the mount.

The main structural members (strongbacks, elevation pivot, and mounting sleeve) of DP&W's top-of-pole mounts are manufactured from heavy gauge steel

Way cool—pole mounts allow air flow around the PVs. Cooler PVs have higher outputs.

The mount's steel and aluminum construction is designed to withstand 90 mph winds.

Pole mounted PVs are easier to install, maintain, and adjust than roof mounted PVs.

(ASTM A36 and ASTM A500–Grade B). The steel components are cleanly mig welded and painted with a minimum of two coats of urethane enamel to protect them from the elements. The strongbacks included in the mount we tested are made of 3 inch (7.6 cm) and 2 inch (5 cm) square tubing.

The 2 by 2 inch (5 x 5 cm) module rails are manufactured using mill-finish 6061-T6 structural aluminum angle. Stainless steel PV mounting hardware is supplied with each mount. The standard assembly hardware for the mount is zinc-plated, Grade 5. Assembly hardware for the mount is also available in stainless for coastal environments where corrosion is an issue.

Standard DP&W top-of-pole mounts are designed to withstand 30 pounds per square foot of wind loading, which works out to about 90 mph. DP&W also manufactures custom top-of-pole mounts for locations that experience extremely high winds.

Installation

The DP-TPM8-SR100 we evaluated is mounted on a 6 inch, schedule 40 steel pipe that was purchased at a local plumbing supply house and set in concrete. DP&W's series 120-6 mounting sleeve is designed to fit over this pipe, which has a 6⅝ inch (16.8 cm) outside diameter.

The mounting sleeve is set to true south (true north in the southern hemisphere) using a compass, and securely locked in place using two pairs of set bolts that are factory positioned 90 degrees from each other. The set bolts keep the mounting sleeve from rotating on the pole in high winds.

Next, the three strongbacks (cross-supports) are bolted in place. The aluminum module rails are then bolted to the strongbacks using angle brackets. The PVs are mounted directly to the aluminum rails using the supplied ¼ inch (6 mm) stainless steel mounting hardware.

Setting the elevation arm to its minimum position (15 degrees) makes it easy to mount the PVs to the rails. If we're installing the array on a hot day, we leave the elevation arm at 15 degrees while we wire up the PVs. This allows us to take advantage of the shade the array provides. Otherwise, we set the elevation arm at its maximum position (65 degrees) to minimize overhead work while wiring up the PVs.

Seasonal Adjustment Made Simple
DP&W's top-of-pole mounts are simple to adjust seasonally as the sun's path changes overhead. The 120-6 series mounts have six elevation adjustment settings: 15, 25, 35, 45, 55, and 65 degrees. Custom adjustment settings are available for high and low latitude installations.

The mount's angle adjustment is set using a through-bolt, which eliminates the possibility of slippage. The series 120-6 mount is well balanced over the center pivot bolt, making seasonal adjustment a job one person can handle with ease.

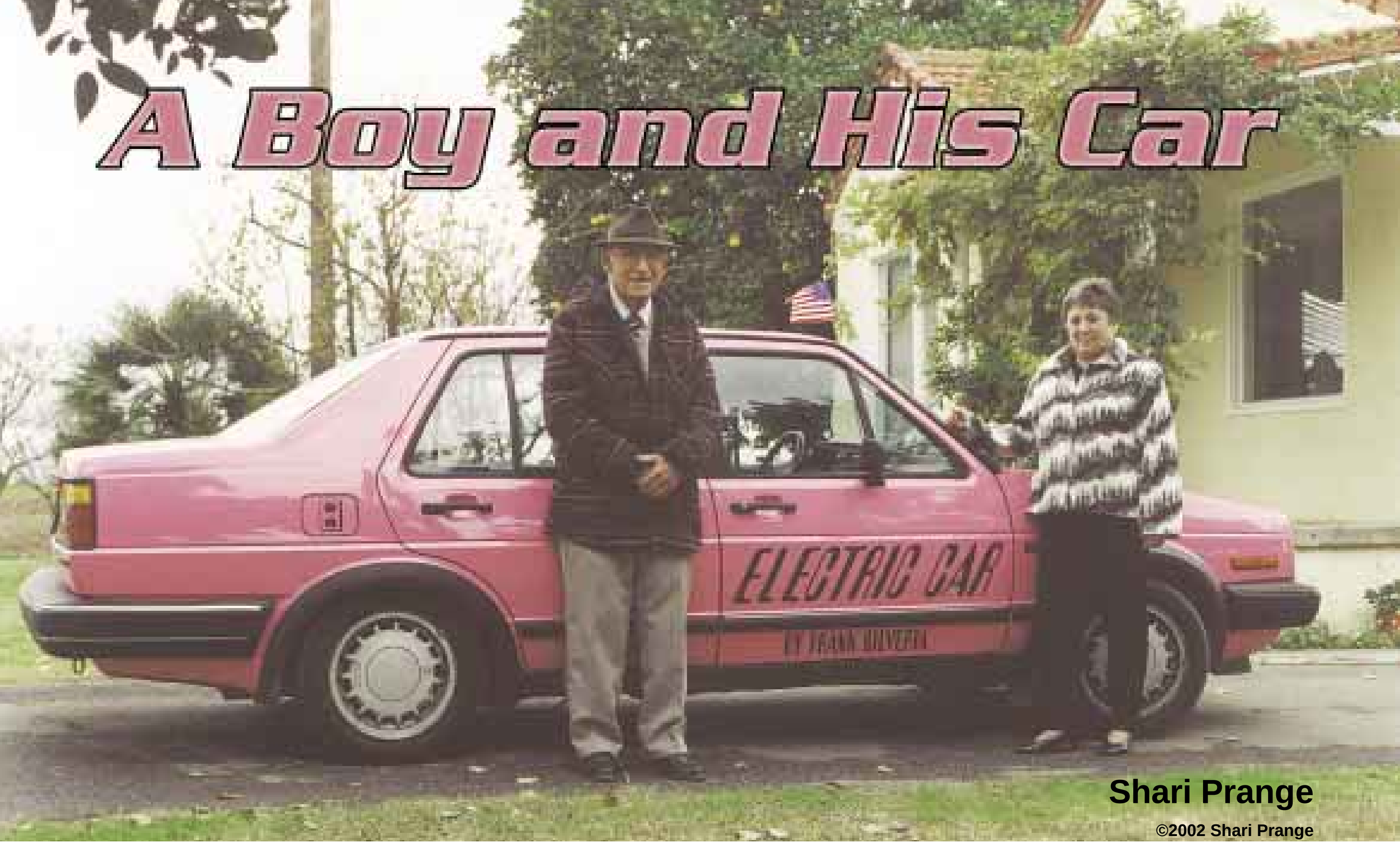
Direct Power
Some sites require roof mounting of PVs to locate the panels in the optimal solar window. But top-of-pole mounts are the best thing going in locations where shading is not an issue and the solar window isn't large enough to justify tracking the array.

Direct Power and Water's top-of-pole mounts are proven in the field. They make for a quick installation, easy seasonal adjustments, and keep your PV modules way cool.

Access
Joe Schwartz, *Home Power,* PO Box 520, Ashland, OR 97520 • 541-512-0201 • joe.schwartz@homepower.com

Direct Power and Water, 4000-B Vassar Dr. NE, Albuquerque, NM 87107 • 800-260-3792 or 505-889-3585 • Fax: 505-889-3548
jrandall@directpower.com • www.directpower.com

A Boy and His Car



Shari Prange

The EV Frank Silveria built for his niece, Mary Mendes, gets noticed!

Frank was bored and restless. Mary knew she had to find a project for him, something big enough to hold his interest and absorb his seemingly endless energy for a while. It was a situation any mother of an adolescent would recognize. Only Mary Mendes wasn't Frank's mother; she was his niece. And Frank Silveria was a long way past adolescence. He was 94 years old.

"Why don't you build me an electric car?" Mary challenged him.

"I don't know anything about cars," Frank said.

"No, but you know about electric motors. Build one for me." Mary replied.

So he did.

Early Training

Frank's preparation to be an electric car builder began when he was a small child growing up in California's Central Valley town of Gustine. When his mother was only twenty-five years old, she lost both her husband and youngest child. This left her as a young widow who spoke little English, with four small children to raise and a farm to run.

Frank was the second oldest, and became the farm handyman. He soon had a reputation for being able to fix any piece of equipment, as well as build original devices. Once, he built his own system for pumping water from the well by using a Model T Ford for power.

At the age of fourteen, his career path was decided by the young girl who would one day be his wife. "I won't marry any farmer," she told him firmly. So Frank began to look around for some other line of work. He started fixing radios. From this, he moved into repairing electric motors, and finally became a fully qualified electrical contractor. By the age of 25, Frank had his own business. When the town of Gustine got its first electric streetlights, it was Frank Silveria who installed them.

Later, the dam at nearby San Luis Reservoir started to have problems. The huge motors used to pump water into the reservoir during off-peak times kept breaking down. Frank, the local electric motor genius, was called

in to fix them. He diagnosed a failure caused by vibrations from the impellers. He repaired and modified the motors, one by one, to make them more durable, and the failures ended.

In the 1950s, Frank moved to the larger town of Los Banos and continued his electrical work. His favorite niece, Mary, worked in the shop under his supervision for many years also. In 1989, at age 83, Frank sold his shop.

With too much energy to "retire," he set up a shop at home, where a large barn and other outbuildings sat filled with a lifetime's accumulation of tools, machinery, parts, and discarded machines waiting to donate usable pieces. He became the person neighbors would call with farm equipment emergencies, or bring motor problems to that no one else could fix.

When Mary needed a place to live that was closer to her work, Frank invited her to move into his house, since he had plenty of room. The stage was set for his adventure into electric car building.

The Main Pieces

Frank and Mary researched electric conversion kits and donor cars. They found a 1987 diesel VW Jetta as the donor car, and chose a conversion kit from Electro Automotive (which was a two-hour drive away in Santa Cruz, California). They chose the car because of the great condition of the body and interior. Mary wanted something attractive that she would be proud to drive. The engine was still in good running condition when they bought it. At US$1,500, they felt that it was an excellent deal.

Frank's mission now was to fit all the pieces together, physically and electrically, into a safe package. With the assistance of Jeff Brubaker, who helped with the heavy lifting, and a couple of consultation visits to Mike Brown at Electro Automotive, that's just what he did. Here are the pieces he used, and where he put them.

The drive system components are popular, off-the-shelf parts for electric car conversions. The motor is a 19 KW brushed, series DC motor from Advanced D.C. Motors in East Syracuse, New York. It is rated for 25.2 hp continuous duty and 85 hp peak on the 120 volt system Frank planned to use. This doesn't sound like much power to people accustomed to hearing about gas cars, but the numbers are deceptive. Electric motors get their highest torque when starting from a standstill, and this system provides plenty of power for the Jetta.

The motor is mounted to the original manual transmission with an aluminum and steel adapter system. The adapter mounts the electric motor to the transmission and clutch in the exact position the engine previously occupied, by means of a pair of precision-machined aluminum plates. The motor shaft is connected to the flywheel by a tapered, split steel bushing inside a matching, tapered steel hub. Once tightened into place, this grips the motor shaft with an even, secure pressure all around.

The speed controller is a pulse width modulated unit from Curtis/PMC of Dublin, California. The controller is, in basic terms, a very sophisticated switch. It turns the full battery pack potential of 120 volts on and off 15,000 times per second, feeding this to the motor.

A few batteries and most of the components live under the hood.

"Pulse width modulated" means that the number of pulses per second remains constant. Speed is controlled by varying the duration, or width, of each "on" pulse. The end result is that the motor's momentum carries it through the tiny "off" pulses smoothly, so it feels like continuous power. Frank mounted the controller behind the front grill, where the radiator used to live. This is a good place for it to get the cooling airflow it needs.

The speed controller determines how much to "chop" the pulse based on the signal from a 0 to 5,000 ohm potentiometer connected to the throttle pedal. The electricity to power the motor comes to the controller from a pack of fifteen golf cart batteries, wired in series for a total pack voltage of 120 volts.

Frank decided to go with 8 volt batteries from U.S. Battery in Corona, California, rather than the more commonly used 6 volt batteries. This was a trade-off between range and performance. Mary's range needs were modest. Using the 8 volt batteries meant a slightly lighter pack (with slightly less range), but a higher pack voltage, for a higher top speed.

These are flooded, lead-acid batteries, so they will need to be watered from time to time—probably more often in the hot summers of Los Banos than they would in milder climates. They are "traction" batteries, designed to move a vehicle. Unlike regular car starting batteries, they can take repeated deep discharges for hundreds of cycles. Unlike marine or RV batteries, they can also take the high current draws of an electric vehicle.

Frank packaged the batteries in polypropylene boxes. This makes an attractive, acid-proof container that isolates the batteries, their connections, and their acid or fumes from the chassis and passengers. He bought the plastic sheet in Sacramento, and built the boxes himself. He didn't weld them, since that requires special equipment. Instead, he bolted them together.

The boxes were then clamped into steel racks, with one part supporting and securing the boxes from below, and a second part framing the top of the boxes. All of this was firmly bolted to the chassis to keep the batteries securely in place, even in a collision. The steel racks are powder coated to give them extra protection from rust and corrosion.

Five batteries are in front, under the hood. Ten more batteries are in the trunk. Most of the rear batteries are recessed into the floor of the trunk to keep the weight low for stability. The back seat is still fully usable for passengers.

The other main component of the drive system is the onboard charger from Russco, of Santa Rosa, California. The charger plugs into a normal household 120 volt grounded receptacle on a 15 amp circuit. If the battery pack is completely discharged, it will fully recharge overnight, gradually tapering to a low current "finish" charge as the batteries come up to full.

Minor Pieces

Other small but necessary parts went into the conversion, as well. These include dash gauges for information on electricity use, a circuit breaker, an on/off main contactor, and fusible links for safety power disconnects. An ordinary 12 volt battery powers the horn, lights, and other accessories. It is kept charged by a DC-to-DC converter that taps the main battery pack at high voltage and low current and converts this into a low voltage, higher current output appropriate for the accessory battery.

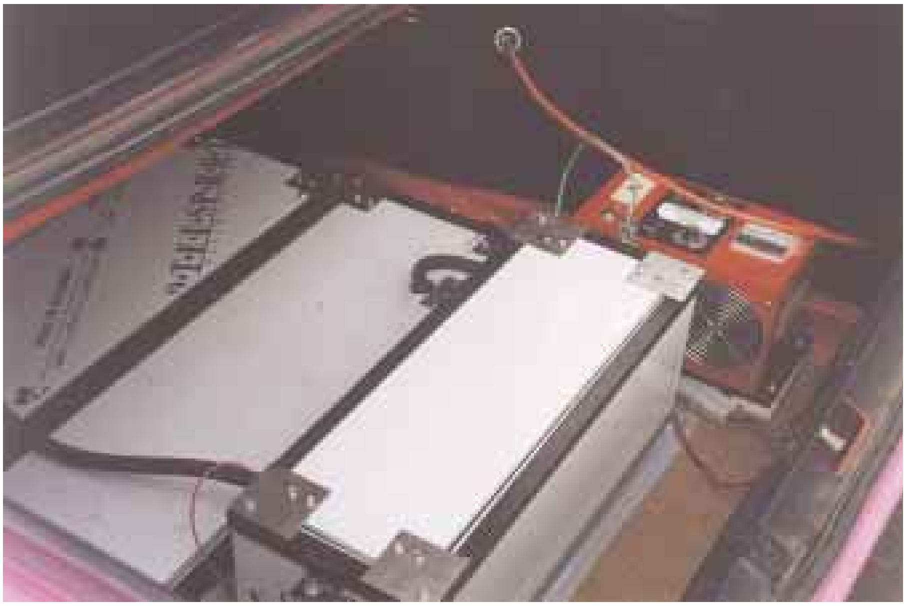
The car had factory power brakes. This is a good thing, because it gained several hundred pounds in the course of the conversion. Since there is no longer any engine manifold vacuum to power this system, a substitute arrangement had to be made. This involves a small electric vacuum pump powered by the accessory battery, a vacuum switch, an ABS plastic vacuum reservoir, and some brass fittings and hoses.

Of these items, the gauges and circuit breaker are the only ones in the passenger compartment. The rest are all installed under the hood.

The Jetta also came with power steering. This could have been maintained in the conversion, but not as easily or affordably as the power brakes. Considering the size of the car, power steering wasn't really necessary, so Frank simply removed it and replaced it with a manual steering rack.

The final area of concern was the suspension. Frank left this until last, to see just how much adjustment it would need in its new configuration. When the car was completed, it drove well with the existing suspension, albeit somewhat lower than the original. Frank still plans to beef this up, but it doesn't seem to be an urgent issue.

Most of the batteries and the charger are in the trunk.



Oh, and one more thing—the paint job. Mary wanted to be sure that the car got noticed, so she had it painted hot pink. For good measure, she added lettering on the doors that reads, “Electric Car by Frank Silveria.” The former gas cap, which now covers the charging cord, sports an icon of an electrical outlet.

The fuel port now accepts a different type of juice.

The Masterpiece

At last, after six months, it was done. The car was finished just in time to make its debut in the town’s Christmas parade. Taking advantage of the car’s available electricity, Frank and Mary trimmed the car with Christmas lights to get into the spirit of things.

Mary is delighted with her car. It drives just like any other car in traffic, and handles very well, even without any suspension modifications. The lack of power steering is not noticeable. Mary’s round trip into town is 8 to 10 miles (13–16 km), and she has made as many as three trips in the same day. Range will improve as the batteries continue to break in.

Mary is also learning some new electric car driving skills. At the beginning, she found that she could start in first, and shift directly into third. This felt fine, but she learned that it was not very efficient and shortened her range. For the low speed driving she does most of the time, driving in second gear is more appropriate and gives her better mileage. She has also discovered that she can release the throttle long in advance of a stop and coast for quite a distance, slowing down much more gradually than in a gas car. This technique adds to efficiency, too.

Performance is better than Mary expected. (She doesn’t *always* drive slowly!) She has had the car up to 65 mph (105 kph), and brags that she can peel out from a stop quite impressively too.

Mary loves the attention the car gets. The hot pink catches people’s eyes first. Then they read the lettering. If she’s in motion, Mary sees the smiles, wide eyes, pointing fingers, and waves. If she’s parked, she knows she’ll soon attract a crowd full of questions.

While the car was being built, Mary’s gas car began to show its age, so she decided to buy a new Toyota Solara sport coupe. She likes it a lot, but since the Jetta hit the road, the Toyota spends much of its time in the garage. Mary’s sister asked her why she has that nice new car and never drives it. Mary replied, “Because driving the electric car is so much more fun!”

Boys Will Be Boys

Shortly after the car was finished, Frank celebrated his 95th birthday, and will soon be fidgeting for a new project. If you ask him about the electric car, he’ll be happy to open the hood and give you the grand tour, explaining every piece and what he did to put it where it is. And when you look at his face, you’ll see the big grin of one very satisfied kid.

Access

Shari Prange, Electro Automotive, PO Box 1113-HP, Felton, CA 95018 • 831-429-1989 • Fax: 831-429-1907 shari.prange@homepower.com • www.electroauto.com

Frank Silveria & Mary Mendes, 21480 W. Sunset Ave., Los Banos, CA 93635 • 209-826-4382

U.S. Battery Manufacturing Co., 1675 Sampson Ave., Corona, CA 92879 • 800-695-0945 or 909-371-8090 Fax: 909-371-4671 • info@usbattery.com www.usbattery.com • Batteries

Russco Electro-Mechanical Engineering, PO Box 3761, Santa Rosa, CA 95402 • Phone/Fax: 707-542-4151 Charger

Advanced D.C. Motors, 6268 East Molloy Rd., East Syracuse, NY 13057 • 315-434-9393 Fax: 315-432-9290 • info@adcmotors.com www.adcmotors.com

Where to Get It:

A Guide to Finding the Little Parts for an EV Conversion Project

Mike Brown

"Where do you get the pipe spacers you mentioned in your column about mounting gauges in an EV?"

I get ideas for my column from many places. Sometimes it's in an e-mail from a reader, a phone call, or even a letter. This issue's question came from Ian Woofenden, my editor at *Home Power.* He was asking the question to help eliminate any confusion on the part of readers.

What he also did was make me aware that I had fallen into a bad habit of assuming that everybody knows *that,* or how to do *this.* After being in this business for so many years, I have accumulated a lot of useful sources that I take for granted. I forget that everybody else may not know about them. So this time I'll share some of them with you.

What Are You Looking For?

Only a few model-specific custom conversion kits include all the parts needed. So the home converter will have to locate, buy, and sometimes build some of the parts necessary to complete a conversion. Let's assume that you have the skills and tooling necessary to fabricate the parts, or know somebody who does. See *HP83* for a column on how to find help with your EV project.

The purpose of this column is to show you how and where to find the things you will need to do a conversion, beyond the electric drive system components you will get in a typical conversion kit. These things fall into four groups.

The first group is materials: plastics, wood, metal, or fiberglass supplies. These are the raw materials that will be cut, formed, and assembled to make the parts you need. This group also includes specialty paints and adhesives.

The second group is modifiable parts. These are manufactured parts that you will modify to fit your needs. This includes PVC pipe and fittings used in irrigation systems, which also work as parts of the battery box ventilation system. The pipe spacers mentioned above can come from the plumbing supply section of a hardware store or the lamp parts section of a lighting store. I have seen Tupperware containers used as weatherproof housings for delicate electrical components.

The third group is manufactured parts: fans, relays, switches, fuse blocks, and other electrical or electronic parts.

The fourth group is specialty fasteners, hardware, and tools. Any fastener exposed to the battery pack should be stainless steel. There are inserts that provide durable threads in plastic or wood battery boxes, and Rivnuts that do the same thing for thin body sheet metal. The tools that install Rivnuts and inserts are part of this group. Clamps, hole saws, and other specialized tools to make the job easier are in this group as well.

Materials

There are various ways to find suppliers, both locally and distant. I'll use materials for the battery rack and battery boxes as a search example. Since battery racks are usually made of metal, which is heavy and bulky, you don't want to pay packing and freight charges. Sheets of plastic or plywood for battery boxes are sold by the four by eight foot panel, which presents the same shipping and handling expenses and problems. You want to find these materials locally, so you can do the hauling.

For smaller mounts, brackets, etc., you will sometimes want special materials that are easily shipped. For example, I use a lot of Extren, which is a lightweight extruded fiberglass. It comes in three foot lengths, in various sizes and shapes. The 90 degree angle stock is very useful. I order this from Small Parts, Inc. in Florida.

The start of every search should be a stroll with your fingers through the Yellow Pages. Search for the material you are looking for by name. If you need steel, look under "Steel." Looking under "Metal" in most Yellow Pages won't get you as many sources as looking for a specific metal, such as aluminum. All the various kinds of plastics, on the other hand, seem to get put in one general "Plastics" listing. Fiberglass supplies, which are a form of plastic, usually have their own listing.

If you find local suppliers, call them with a list of your needs, and see if they can help you. In addition to getting the price and availability of the material, be sure to ask what their cutting charge is. Cutting the material at least once at the source is almost always a necessity.

In the case of plastic sheets or plywood, if the cutting charge is reasonable, give them a list of the lengths and

widths of each part of the box you need. Having the supplier cut the material may save you a lot of time and effort, in addition to getting more accurate cuts, straight edges, and true angles.

If you strike out in your local area, look in the Yellow Pages for the nearest larger town or city within easy driving distance. These Yellow Pages can usually be found in your public library or on the Internet at www.yellowpages.com.

If you live more than a day's drive from anywhere that has the material that you need, look in the local Yellow Pages for a welding shop, metal fabricator, or farm machinery repair shop for metals. In the case of plastics, try to find a sign shop. If you find someone who uses the material you need or has a source for it, ask them if they would include your material list in their next order to their supplier. Lumberyards for the plywood are pretty universal, and would also be a likely source of paints and adhesives.

Some suppliers don't appear to be a likely source of material. I found some urethane foam sheet stock that I needed for battery box insulation in a surfboard supply shop. They also had a better deal on fiberglass cloth and epoxy resin than I could get elsewhere. Another time, I found a small swivel I needed in the fishing tackle department at an outdoor goods store.

Try to think about other products that use the same material or part you need. I knew that surfboards are made with urethane foam and fiberglass. Or just walk through various kinds of stores and scan the shelves for inspiration. Bicycle shops are a good source of control cables, and I have perused skateboard shops just to learn what they had that I might want to use in the future.

Anytime you visit the suppliers you have found in person, be sure to look around and check out the other things that they carry. Something that you spot might be a modifiable part.

Modifiable Parts
A modifiable part, as mentioned previously, is a part made for one use that you modify for another use in your EV. Because of the need to take measurements, make trial fits to other parts, and in general handle it (the "fondle factor"), a modifiable part is best searched for and bought in person from a local source.

Local sources can be hardware stores, plumbing supply companies, irrigation supply stores, electrical supply houses, or the "big box" home improvement centers that combine all of the above into one location. Other possible businesses are hydraulic hose supply and repair shops, sheet metal and heating companies, boat

Parts, Materials, & Tool Sources

Aircraft Spruce, 225 Airport Circle, Corona, CA 92880
877-477-7823 or 909-372-9555 • Fax: 909-372-0555
info@aircraftspruce.com • www.aircraftspruce.com
Materials, fasteners, tools

Eastwood Company, 263 Shoemaker Rd., Pottstown, PA 19464 • 800-345-1178 or 610-323-2200
Fax: 610-323-6269 • techelp@eastwoodcompany.com
www.eastwoodcompany.com • Specialty automotive tools & supplies

Griot's Garage, Inc., 3500-A 20th St. East, Tacoma, WA 98424 • 800-345-5789 or 253-922-2400
Fax: 253-922-7500 • sales@griotsgarage.com
www.griotsgarage.com • Specialty auto parts & supplies

Jameco, 1355 Shoreway Rd., Belmont, CA 94002
800-831-4242 or 650-592-8097 • Fax: 800-237-6948 or 650-592-2503 • info@jameco.com • www.jameco.com
Electronic & electrical parts

Marlin P. Jones and Assoc., PO Box 530400, Lake Park, FL 33403 • 800-652-6733 or 561-848-8236
Fax: 800-432-9937 or 561-844-8764 • mpja@mpja.com
www.mpja.com • Surplus electronic & electrical parts

Northern Tool & Equipment Company, PO Box 1499, Burnsville, MN 55337 • 800-533-5545 or 612-894-8310
Fax: 612-894-0083 • hal@northern-online.com
www.northern-online.com • Tools & equipment at good prices

The Olander Company, 144 Commercial St., Sunnyvale, CA 94086 • 800-538-1500 or 408-735-1850
Fax: 408-735-6515 • customercare@olander.com
www.olander.com • Hard-to-find hardware & tools

Orchard Supply Hardware, 6450 Via Del Oro, San Jose, CA 95119 • 888-746-7674 or 408-281-3500
www.osh.com • Tools, fasteners, materials

Reid Tool Supply Company, 2265 Black Creek Rd., Muskegon, MI 49444 • 800-253-0421 or 231-777-3951
Fax: 231-773-4485 • mail@reidtool.com
www.reidtool.com • Tools & fasteners

Small Parts, Inc., PO Box 4650, Miami Lakes, FL 33014
800-220-4242 or 305-557-7955 • Fax: 800-423-9009 or 305-558-0509 • parts@smallparts.com
www.smallparts.com • Parts, tools, materials

Surplus Center, PO Box 82209, Lincoln NE 68501
800-488-3407 or 402-474-4055 • Fax: 402-474-5198
Electrical & hydraulic parts

West Marine, PO Box 50070, Watsonville, CA 95077
800-262-8464 or 831-761-4800 • Fax: 831-761-4421
webmaster@westmarine.com • www.westmarine.com
Stainless steel hardware & fasteners, fans & electrical supplies

or marine supply stores (West Marine is a nationwide company), and our old standby, the independent auto parts house.

Industrial surplus stores are often a treasure chest of modifiable parts. These stores deal in odd lots of leftover parts, fasteners, and equipment from local industry, and not camouflage clothes and hunting and fishing supplies. Make sure which type of surplus store it is before you make the trip.

Manufactured Components

Manufactured components are parts that are built to do a specific job. You may not be using them in the application for which they were designed, but switches still switch, relays switch electrically, fans cool or ventilate, and fuse blocks protect circuits and other components.

Again because of the fondle factor, it's best to buy these parts locally if you can. In addition, a knowledgeable salesperson may know of a reason why the relay you have selected, for example, may not be suitable for your application, and may suggest another one that is.

If finding a local supplier is not possible, use the next option in our bag of search tools—catalogs. There are disadvantages to buying from a catalog, including the absence of the I've-got-it-in-my-hand-now feeling, the necessity to have the right catalog in the first place, and the reduced availability of technical help.

Developing your patience is the answer to the first issue. The answer to the second problem is in your public library. Almost all public libraries, with the exception of small branch libraries, have the *Thomas Register* books. This is a multivolume set of large green books. Almost all industrial products and services available in this country are listed alphabetically in them.

Looking up "Fans-DC" will get you listings of manufacturers, as well as their distributors in every state where they are represented, with their contact information. In the "TomCat" section of the *Register,* some companies publish their catalogs.

Here's the method I developed for using the *Thomas Register:* First, I locate the product I'm looking for. Next, I write down the contact info for the manufacturer's representative or distributor in my area. I always write down all the closest companies in case I contact one that isn't cooperative.

When I get home from the library, I call one of the distributors I've written down, ask for a salesperson, and explain my needs to him or her. If the distributor has what I need, I ask for a catalog from the part manufacturer, and a line card from the distributor.

The manufacturer's catalog gives me the dimensions of the part, its ratings, and the ordering codes. This fills the gap in technical information mentioned earlier, and makes sure that the salesperson and I are talking about the same part. The line card is a list of the other lines of parts the company carries, which might include other things I am looking for.

Hardware & Tools

Fasteners could be the subject of another whole column. Common nuts, bolts, and washers are usually found in hardware stores, lumberyards, and auto parts houses. As long as the nuts and bolts are labeled as Grade 5, you should not have problems with quality or strength. When you get into the world of specialty fasteners, the search for the right bolt at a good price gets harder.

Most ordinary hardware stores carry a limited selection of fasteners like allen head cap screws, flat head machine screws, or anything made out of stainless steel. A lack of selection and high prices for what they have usually means finding another source. If you live in California, look for an Orchard Supply Hardware (OSH) store. This company built its reputation on its fastener and industrial supply departments. It would be harder for me to do what I do without an OSH store nearby.

If you don't have an OSH store or the equivalent in your area, it's time to hit the Yellow Pages again. The listing in my phone book is "Fasteners-Industrial." For stainless steel fasteners, try a boating or marine supply store.

If all else fails, there is still the catalog route. The catalog method is harder because you can't handle the parts, you need to know in advance what you want, and you must know how to place the order so you actually get what you want. But it can be done. I have included some of my favorite fastener suppliers in the sources sidebar.

The procedure for finding the ordinary and special tools you might need to do your conversion is the same one used for finding manufactured components and fasteners. Buy locally if possible (fondle factor, again), and if that's not possible, hit the catalogs. Be careful reading tool catalogs. You can eat up a lot of time just looking. What's even more dangerous is that looking may lead to an expensive habit—excessive tool buying.

Casting Your Net Wider

So far we have been conducting our searches using the basics—Yellow Pages, phone calls, and personal visits. We expanded our horizons with a trip to the library and a look at the *Thomas Register* to locate sources of catalogs for parts we need. Now it's time to look at the goods and services catalog for the world—the Internet.

If you have a computer with an Internet connection at home, at work, or even if you have to go to the library and use theirs, you should be able to find what you need. Just for a start, the complete *Thomas Register* is on the Internet (www.thomasregister.com). Their Web site gives you a choice of searching for a product or a service, a company name, or brand name, and you can further limit the search to your own state.

When you enter the product you are searching for on the Thomas Web site, a page comes up listing the product headings that include your search words. When you enter the heading you want, you get a page with a table listing the companies that have the product you want, and a brief description of their product lines. Clicking on the company name gets you the basic contact information—address, phone number, fax number, and Web address if they have one.

As you move to the right on the table, boxes with buttons in them give you the option to view an online catalog or go directly to the company's Web site. The other options offered are placing an order, viewing a CAD drawing of the product, or sending e-mail to the company. Not all of the companies listed offer all the options.

The Thomas Web site is a free site, but you have to fill out a registration form to get access. You don't have to be a business to use the service, so skipping the company name box on the registration form won't hurt anything. Once you are registered, you will be welcomed back to the site by name.

This is just one way to locate a product on the Internet. Going to a search engine such as www.google.com and starting a search with the name of the product you need will get you links to more Web sites than you could possibly use.

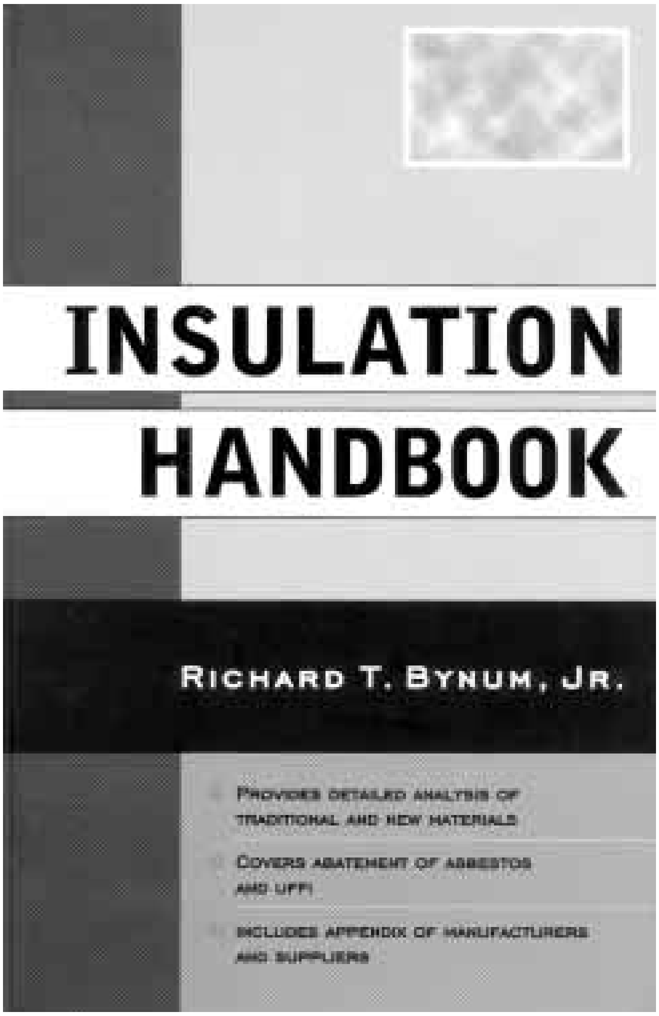
Most companies' Web sites have a catalog of their products with specifications and dimensioned drawings. So deciding if a part is what you want is easier. The site should also give you a list of the company's distributors or sales outlets.

Boldly Go...
The purpose of this article was to show you how I have found the small parts that I use to do conversions. You saw how I did it in the past, and how using the Internet speeds up that process. Be creative in your searches, and don't limit yourself to the same old sources.

Look for ways to adapt something from one purpose to another. Investigate unlikely but interesting places, and be alert for things that might come in handy in the future. Observe how other people have solved problems similar to yours in different applications.

I have included a sidebar with some of my favorite sources for things listed. I hope it helps. I would also like to hear about any useful sources you have. Good hunting.

Access
Mike Brown, Electro Automotive, PO Box 1113-HP, Felton, CA 95018 • 831-429-1989 • Fax: 831-429-1907 mike.brown@homepower.com • www.electroauto.com



Reviewed by Pete Gruendeman

Home Power readers do a lot of things for themselves. In all cases, we need plenty of information to guide us so we don't have to do things over and over again. When I was looking for guidance on what type of insulation to use in my home-built refrigerator, I turned to Richard Bynum's *Insulation Handbook.*

Walk into any lumberyard or do-it-yourself store and you will see a bewildering array of insulation types, ranging from rigid boards to rolls and batts of fiberglass. These can come with or without paper backing, radiant barriers, or vapor barriers. How can anyone know what to buy and how to use it properly?

Insulation Handbook is an unbiased application guide. The author describes many types of insulation for use in and around the home. In each of seventeen chapters, he describes a particular type or class of insulation, its uses and performance specifications, possible installation pitfalls, and health and environmental issues for each.

The author gives comprehensive information about vapor barriers; loose fill insulation; fiberglass batts and rolls; sprayed in place, foamed in place, and rigid board insulations; and radiant barriers. Earth-bermed construction and integrated insulation systems are covered, as well as nineteen pages on straw bale construction. The book concludes with chapters on historical insulation products and future insulation products. An appendix contains some 65 pages of facts, figures, and contact information.

Many things must be considered when selecting insulation. Aside from the different R-values, factors to consider are long-term resistance to moisture, insects, rodents, and even fire. There are also environmental issues in manufacturing the stuff, and environmental issues in the home, such as hazardous dust released during the installation process.

Insulation Handbook answered all of these questions and some I had not thought of, with no bias towards any particular product or manufacturer. You just don't get this kind of objectivity when reviewing manufacturers' literature.

Architects, contractors, and home owners alike will find *Insulation Handbook* to be most valuable for getting the greatest comfort and longest lasting insulation performance in any new construction or home remodeling project.

Access

Pete Gruendeman, 50 Washington Rd., Princeton Junction, NJ 08550 • 609-466-2175
gruendeman@worldnet.att.net

Insulation Handbook, by Richard T. Bynum, Jr.,
ISBN 0-07-134872-7, 2001, 494 pages, US$59.95 from McGraw Hill, 860 Taylor Station Rd., Blacklick, OH 43004 • 800-262-4729 or 609-426-5793
Fax: 614-759-3641
customer.service@mcgraw-hill.com
www.books.mcgraw-hill.com

Renewable Energy Terms

Watts per Hour? Amps per Hour? No Such Things!

Ian Woofenden

Would you trust a car salesman who told you that the cruiser you were drooling over got 25 miles per gallon per hour? Or what if a prospective employer said that your pay would be $10 per hour per day?

I hope you'd be scratching your head and walking the other way. Does the salesman mean 25 miles per gallon, or 25 miles per hour? Does the employer mean $10 per hour, or $10 per day? It can't be both. These nonsensical uses of the terminology should be enough to warn you that the person you're talking to is confused at best. It's the same with the phrases "watts per hour" and "amps per hour."

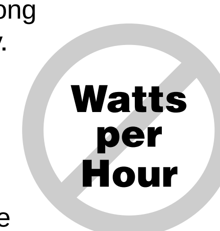
Electrical terminology confusion is a little harder to recognize, and perhaps a bit easier to forgive. The terms do make it tough. When you say "miles per gallon" or "dollars per hour," you know that you're talking about a rate. That "per" is the tip-off.

What's easy to overlook is that "watt" is shorthand for "joules per second," and "amp" is short for "coulombs per second." So "watts per hour" translates into "joules per second per hour," which doesn't make any sense. It can't be both joules per second and joules per hour.

A watt is a rate of energy use, consumption, or transfer. A typical compact fluorescent lightbulb uses energy at the rate of 20 watts. Think "joules per second" every time you say "watt," and see if it makes sense. A joule is a certain amount of energy.

An amp is a rate of charge flow. A certain PV panel might produce at the rate of 5 amps in full sun. Think "coulombs per second" whenever you say "amp" to see if it works. A coulomb is a certain amount of charge.

So the lightbulb mentioned above, if left on, will draw 20 watts all day long. It's drawing 20 watts at lunch, 20 watts at tea time, and 20 watts at dinner. The PV panel will produce at the rate of 5 amps as long as the sun stays at that peak intensity. "Watt" and "amp" are instantaneous measurements of *rates,* like miles per hour and gallons per second.



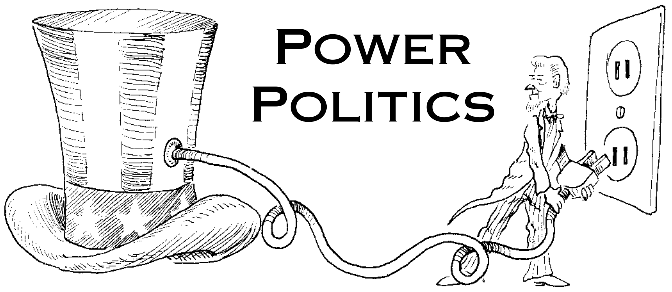
When we want to talk about accumulated charge or energy, we use the terms "watt-hours" and "amp-hours." That 20 watt light, left on for an hour, will use 20 watt-hours of energy. After an hour in the sun, the 5 amp PV panel will have pumped 5 amp-hours of charge through the battery. Watts times hours equals watt-hours. Amps times hours equals amp-hours. There's no such thing as "watts per hour" or "amps per hour."

Part of the confusion may come from the use of "w/h" and "a/h" as abbreviations for "watt-hours" and "amp-hours." That's incorrect notation, since the slash means "divided by" and is commonly read as "per." It's much clearer to abbreviate them as "WH" and "AH," "W-H" and "A-H," or as in scientific notation, "Wh" and "Ah." The phrase "ampere-hour" may sound like "amp per hour." But it's simply the long form of the term "amp-hour," since "amp" is short for "ampere."

The terms watt and amp designate rates. The terms watt-hour and amp-hour designate quantities of energy and charge. Keep them straight if you want to understand and be understood when talking electricity. And think twice about buying a lightbulb or an RE system from someone who says "watts per hour" or "amps per hour"...

Access

Ian Woofenden, PO Box 1001, Anacortes, WA 98221
Fax: 360-293-7034 • ian.woofenden@homepower.com



Enron Holds a Plant Sale

...Bake Sale Next?

Michael Welch

It has been hard to find a daily newspaper that doesn't contain multiple articles about energy broker Enron's woes and wrongdoing. The management of Enron inflated income reporting by an annual average of about US$120 million from 1997 through 2000, and possibly before. They also underreported their financial liabilities. Then a proposed cash-infusing merger with Dynergy, another energy company, failed because Enron's financial situation was looking too bad even for them. Enron had no choice but to cover its butt by filing for bankruptcy.

Unfortunately, innocent shareholders lost billions of dollars when Enron stock plummeted from a high of US$90.75 per share during the time of falsified reporting, to US$8.50 per share when the falsifications were revealed. As of the middle of January, when the stock exchange finally put a halt to Enron trading, the value was US$0.67 per share.

Inflated income reporting is not the end of the shenanigans this company has been involved with, and shareholders are not the only harmed group. Let's take a look at Enron's recent impacts on the world of energy.

The company was nearly unheard of until just a few years ago. But as of last year, it had hit the seventh highest position on the Fortune 500 list of corporations with the highest revenues. They did not really make a product for sale. Most of their revenue was from buying gas and electricity at very low prices in huge quantities, and reselling it to consumers at a profit.

This is not much different from what any retailer or wholesaler does, except for a very important factor. There is enough competition in most industries to make sure that market manipulations do not drive prices up too high. In other words, if the price of one brand of widget gets too high, you either use a different brand, or do without. In the gas and electric industries, there are no alternative choices. Customers got so used to an inexpensive product that high consumption became deeply ingrained in U.S. society, and people didn't know how to do without.

Until recently, gas and electricity prices were tightly regulated to make sure that energy monopolies did not take advantage of their customers. Then in an effort to decrease retail electricity prices, large energy consumers, like mining and manufacturing interests, decided that they wanted to open up California's retail electric markets to increased competition.

At first, only the manufacturers and consumer groups were interested in this new industry restructuring. But as the plan started to get some momentum, the utilities got involved to protect their own interests, and the wholesalers and potential remarketers got involved to do the same.

Suddenly, several very powerful special interests had gained control of the process. One of those was Enron, which stood to gain an awful lot if they could both control supply and remove regulation. They were able to get nearly everything they wanted out of California's utility restructuring.

For the most part, Enron built their new type of energy marketing business out of nothing. If everyone in the energy business is making money, and some new megacorporation comes in and needs to make the big bucks as well, that can only mean that the end consumer is going to pay through the nose. But the less-told story is how the federal government helped them out.

Corporate Contributions & Lobbying

Enron was one of the biggest campaign contributors in the U.S., giving nearly US$6 million to parties and federal candidates between 1989 and 2001, and

spending about US$7 million on federal lobbying. They were George W. Bush's largest contributor, to the tune of more than US$2 million, via the company and its executives over his whole political career. Though not nearly as hefty, they also made contributions to both the Bush 1 and Clinton administrations.

Corporations don't do this out of the goodness of their hearts—they expect something in return. The political payback to Enron has been ongoing, but very notable paybacks surround last year's energy "crisis" in California.

It is the Federal Energy Regulatory Commission's (FERC) job to monitor energy prices, to make sure that companies are not gouging customers and manipulating supplies. In spite of encouragement by eight western governors and twenty members of California's congressional delegation, FERC refused to intervene to end California's energy problems.

"It seems clear that the Bush administration is trying to return the favors done by friends and donors," said Joan Claybrook, president of the consumer advocate organization, Public Citizen. "Bush is helping out his buddies at the expense of every consumer in California, and his refusal to cap wholesale prices is threatening to wreak havoc on the entire western region of the United States."

The Bush administration legally had the right to intervene, but chose not to, which benefited Enron and a handful of other energy companies. This cost Californians dearly, and now the state has a US$9 billion deficit to show for it. California's largest utility went bankrupt in part because of skyrocketing wholesale energy prices.

Funny thing, after state and federal controls were finally implemented, the rolling blackouts stopped, consumers could afford to pay their bills, and energy companies were still making a reasonable profit. How Californians should feel about Enron was summed up by California Attorney General Bill Lockyer: "I would love to personally escort (Enron CEO) Lay to an 8 by 10 cell that he could share with a tattooed dude..." [*editor's note:* Home Power *is not anti-tattoo.*]

U.S. Senator Phil Gramm of Texas was another major recipient of Enron's campaign contributions. Gramm's wife, Wendy, was chair of the Commodity Futures Trading Commission during the Reagan and Bush 1 presidencies. According to Public Citizen's "Blind Faith," a report on restructuring and Enron's influence-buying, Wendy Gramm exempted Enron from commodities trading regulations, giving them the ability to manipulate energy market prices.

She did this just days before leaving office as the Clinton administration was taking over. This was right before she was awarded a seat on Enron's board of directors, where she served on the board's audit committee. She was paid between US$0.9 and US$1.85 million for her work with Enron.

Husband Phil Gramm also promoted Enron's interests. In December 2000, he helped force a bill through Congress without a committee hearing. This bill further deregulated energy commodity trading and allowed Enron to operate an unregulated electricity auction that quickly gained control over a significant share of California's electricity and natural gas markets.

Current Energy Plan

Enron's campaign contributions and lobbying also could account for several items that were included in Bush 2's energy plan that would benefit the company. These items were echoed in the energy bill that passed the House last fall and is being considered by the Senate now.

A report for the House of Representatives Committee on Government Reform identified seventeen areas of the energy plan that were supported by and would benefit Enron, including:

- Removing regulation over electric transmission lines from states and giving them to the feds, where companies like Enron would have an easier time gaining access and control.
- Repealing the Public Utility Holding Company Act, which limits the types of activities that a public utility holding company can undertake. If repealed, Enron would be allowed to purchase more utilities than the one that it now owns (Portland General Electric), and would still be allowed to participate in its commodities markets.
- Instituting federal eminent domain for condemnation in electric transmission line siting, which would supersede states' rights in this area.
- Beginning incentives that would allow greater profits than the normal rate of return on investments in transmission lines.
- Expanding markets and opening new ones for the trading of emissions credits.
- Expediting permits for new electric production facilities by weakening environmental review.
- Supporting Enron and other energy firms in gaining foreign energy investments.

Enron-omics

Since Enron was so heavily involved in the financing of

energy, rather than its production, they required a lot of credit to buy and sell energy. When Enron failed, it really hurt its creditors, at least in the short term. They will likely get their money back. But the larger problem is that it has really soured investment firms on energy projects, and this may affect renewables.

Were Enron's influence-buying efforts and financial shenanigans any different than what other large corporations do? Methinks that the only major difference was a dose of stupidity, and the fact that they got caught. Most Fortune 500 companies are involved in this kind of thing, at least to some degree.

These guys should be going to jail, but I doubt that they will. I recently read about a fellow who may spend several years in jail for stealing food for his family. You can bet that just-resigned Enron CEO Ken Lay will not do a day's worth of time for his multibillion dollar crimes.

What I've presented is just a drop in the bucket compared to the info out there about how Enron has messed with and tried to control the energy world. For an interesting evening, stick the words Enron and corruption, Enron and Gramm, and Enron and India into your favorite Web search engine.

What You Can Do
My editors always want me to talk about what you can do to fix what I complain about. Here you go:

- Do not make paper investments, but rather invest in companies with real products that you believe in.
- Shop locally.
- Consume less.
- Make your own electricity with renewable energy.
- Encourage your elected officials to pass strong campaign contribution and anti-lobbying laws.

Oh yeah, about the title of this column. After the bankruptcy was filed, Enron employees were seen leaving one of their facilities carrying plants. Apparently the corporation had decided to end the greenery maintenance contract, so the plants were sold off to employees.

Access
Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884
michael.welch@homepower.com
www.redwoodalliance.org

The Center for Responsive Politics, 1101 14th St., NW Suite 1030, Washington, DC 20005 • 202-857-0044
Fax: 202-857-7809 • info@crp.org
www.opensecrets.org • Fantastic resource for finding recipients and donors of political money exchanges

Public Citizen's Critical Mass Energy & Environment Program, 215 Pennsylvania Ave. SE, Washington, DC 20003 • 202-546-4996 • Fax: 202-547-7392
cmep@citizen.org • www.citizen.org/cmep

Enron, 1400 Smith St., Houston, TX 77002
713-853-6161 • www.enron.com

Growing Pains

Don Loweburg

It's been about two years since Xantrex purchased Trace Engineering. At the time, there was some concern about possible changes and implications for the industry, given Trace's domination of the small inverter market. That concern was based on some fundamental issues.

The previous corporate culture at Trace was dominated by engineers. Trace was a company founded and run by engineers. In general, an engineering perspective will emphasize technology first. The new owners come from a more traditional corporate background. Xantrex was able to purchase Trace (and two of their West Coast competitors) by borrowing more than US$100 million. To a large extent, this was possible because Xantrex's CEO has contacts and leverage within the financial community. In short, the bean counters and suits took over.

Since the takeover, there have been good and bad changes. On the positive side, Xantrex has attempted to clean up the distribution of its products by discouraging lowball advertising. Though the practical effect may be nil, the gesture is well taken.

Xantrex has also taken the initiative to implement a certified dealer program. Certified dealers must pass a three-hour examination, have field experience, and provide documentation of successful PV system installations. As PV becomes mainstream, it is increasingly important that the industry establish both hardware and installation standards focusing on system issues and performance. Xantrex is supporting these efforts.

There have been bumps in the road. July 2000 saw the rollout of the ST2500, Xantrex's grid-tie-only inverter targeted for the residential market. The press release announcing the ST stated that units installed as part of the California rebate program would enjoy a five-year warranty. Subsequently, Xantrex backed off and only offered the five-year warranty as an after sale purchase option. To this day, Xantrex refuses to acknowledge or publicly retract their initial warranty statement.

A second problem with the ST involved the maximum power point tracking (MPPT). Field reports of low output were traced to problems with the tracking software. The problem was explained as an overly aggressive tracking algorithm that resulted in repeated, inappropriate shutdowns. The software was revised, and in-field reports indicate that it functions well enough.

However, for reasons that are not clear, Xantrex announced its next generation inverter, the STXR, in April 2001. In terms of published specifications, there is no difference in performance between the ST and the STXR. The XR does offer a remote metering option and nonvolatile onboard KWH recording. The biggest complaint is that the STXR is still not available.

The premature public announcements promoting the XR have only churned the already murky water around the ST. Sources in distribution suggest that the STXR won't ship in production quantities until this spring, a full year after its initial promotion.

On November 16th, Xantrex experienced a major pileup when UL revoked its listing for the SW series inverters. The background and inside details surrounding this event are still unclear. The specific reason given for decertification was that the SWs failed to pass an anti-islanding test as part of its listing under UL 1741.

Customers with installed SWs should understand that there is no safety issue here. There have been *zero* islanding problems in the field. The SWs failed a specific and very low-probability simulated event. This failure requires that the inverter loads precisely match the array output (balanced load) exactly when the grid goes down. Under these very specific conditions, the SW may take longer to disconnect from the grid than the time period allowed by UL 1741.

For inverters purchased prior to November 2000, the earlier ETL listing is still valid. Both grid-connected and off-grid systems installed before that date are fully compliant to ETL. SW inverters purchased after November 2000 do carry the UL 1741 certification.

The most affected customers were those who purchased SW inverters planning for grid-tie applications, but hadn't installed them. Without UL certification, some local utilities did not allow interconnection. The California

Energy Commission delisted this inverter, so they didn't qualify for the buydown program.

The SW was the only series affected, and it was a temporary situation. Xantrex came up with a fix that will enable the SWs to pass the islanding test and be relisted. Xantrex has been working with their dealers and distributors, and has reassured all that this problem will be handled with integrity. At a minimum, customers with affected inverters should expect them to be restored to UL compliance at no additional cost.

As I said earlier, the inside details of how this happened are not clear. But I can say that this trouble was brewing for some time. I suspect that Xantrex made unfulfilled promises to UL, and the relationship between the two was allowed to deteriorate to the extent that UL finally pulled the plug on Xantrex.

This was a big deal, but fixable. UL has recently relisted the SW inverter, and the CEC has reinstated the SW series inverters on the approved equipment list. Xantrex now must fix it with their customers, dealers, and distributors. Clear, honest communication with all, coupled with strong action taking financial responsibility for this problem can recover Xantrex's credibility.

The new management at Xantrex must take the heat for the current state of affairs, and re-evaluate those policies that have eroded the company's image. PR and marketing hype are not going to get the job done. At press time, I hear that Xantrex is replacing affected SWs with listed units, and is actively resolving the problem with its customers and dealers. Xantrex, thanks for doing the right thing!

California Utility Restructuring: It's Not Over

One of the greatest shortcomings of California utility restructuring was its failure to produce any significant competition. Since one of the primary stated goals of restructuring was customer "choice," we should now ask what happened.

My view is that real competition was never the goal of restructuring. In fact, significant competition was specifically disallowed by language in the restructuring law that prohibited grouping together of customers. If individual customers had been allowed to aggregate into neighborhoods, co-ops, and even municipal buying groups, competition and choice might have happened. The lesson here for other future attempts at restructuring is to make sure that customer aggregation is allowed. Without provisions for customer aggregation, restructuring is a phony sham!

Shortly after restructuring began in California, it did appear that there was some choice for individual customers. This was because of the marketing of "green power." The hope and assumption was that if customers were able to buy renewably generated electricity, even if it cost a bit more, they would switch to a nonregulated green provider.

Even prior to the meltdown of California's regulated utilities and electricity market, very few customers switched—less than 1 percent. Subsequently, Green Mountain, Enron, and the other green providers dumped their customers back on the regulated utilities when the going got rough.

Today we have a very strange situation in California. Left over as a residue of restructuring, nearly bankrupt regulated utilities are responsible for the distribution of electricity. We also have tremendously enriched unregulated cartels responsible for generation. Add to this very asymmetrical situation the fact that the state of California has liquidated a significant state monetary surplus by buying high priced electricity contracts in an attempt to temper the market.

Maybe the strategy worked; the price for electricity has stopped escalating. But this is not very good business, since the state bought high and is now selling low. In other words, the taxpayers are subsidizing the purchase of electricity in an attempt to stabilize the market. A major problem is that the wrong players are getting the subsidy. These generators are mostly burning fuel to make electricity, and many are the same corporations that screwed Californians last winter and spring.

There is a new concern given that the state of California is now behaving as an electricity broker. Since the state owns a significant amount of electricity under contract, they must move it to market. It seems pretty clear that most of this capacity will be dispatched by the regulated utilities in the state. This relationship and state government's dependence on the regulated utilities to deliver state purchased electricity could compromise the state's position as a regulator working in the public interest.

The state now must protect their new business partners, the utilities. This is not just an abstract scenario. This unsavory alliance has consequences, one of which has already occurred—the elimination of choice and direct access. California utility customers can no longer choose their electricity provider. The state of California has a vested interest in maintaining the regulated utility as sole electricity provider. If the regulated utilities lost their captive customers because of choice, the state of California might be left holding the bag of unsold electricity.

Software Tools

Predicting system output is one of the important tasks provided by good professional installers. In the last several columns, we have discussed simple estimating

methods and suggested software design tools that can refine the estimating process by incorporating specific climatic, module, and siting information. Design software can also be a valuable learning tool useful for running “what if” scenarios. But design software is no substitute for experience, which is necessary to close the loop between prediction and results. When the two agree, then we can claim that we know what we are doing.

Confirming system output can be as simple as attaching a mechanical KWH meter to the output of the inverter. A reconditioned meter and socket cost around US$100, which shouldn’t price anyone out. More elaborate system monitoring is available. In the past, these setups have required input sensors for each logged parameter (volts, watts, amps, etc.) connected to memory modules. The stored data then had to be accessed, often using a phone line and modem. This type of data acquisition system can cost several thousand dollars to set up.

Owners of Trace SW and PS inverters have a lower cost option for system monitoring available. Xantrex markets the SWCA, a hardware-software option for these inverters. The hardware consists of an adapter that plugs into the “remote” port on the inverter. The output of the adapter is in serial format via a standard phone line, and can be connected to a computer serial input or a modem if remote access over a phone is desired. Xantrex provides a software program in DOS that allows viewing and controlling the inverter from a computer.

The utility and value of the SWCA can be significantly increased by using Trace Tools, a Windows software package by Maui Solar Software. The program expands the functionality of the SWCA in three areas. First, the display and access to many settings and screens are greatly improved. When the program is loaded and operating correctly, the primary screen lays out all the settings and meter readings in one view.

Settings and meter readings are logically grouped according to function. The layout is very intuitive. Actual meter readings are displayed in distinctive boxes. To change or adjust any parameter, a user can click on the appropriate box and change values using a “slider” type control. Entire setup configurations can also be saved as files for quick future reloading.

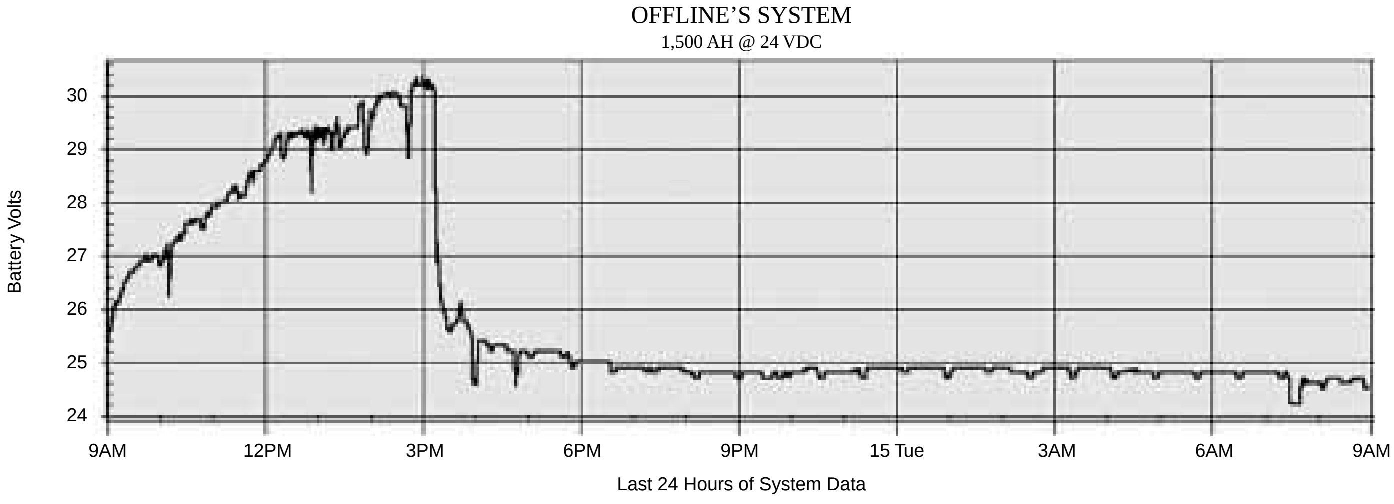
Data logging is the second capability of Trace Tools. While the software is constantly scanning and displaying data to screen, it is also writing that data to memory. From this data file, the program can generate short and long-term graphs of all collected data. Both the data and the graphs can be exported. The graph is of our battery voltage over a 48 hour period.

The third feature offered by Trace Tools is dial-up capability to connect to an off-site SW inverter using a phone. The output of the remote inverter’s SWCA is connected to a modem and phone line. Using this setup, the remote computer can read and control all SW functions, and log data by calling the modem on the phone. The program also has the capability to send e-mail alerts, both when inverter errors are detected and when they are resolved. Trace Tools can also post and update graphs to a selected Web site.

A soon to be added feature of Trace Tools is the logging of array data. Combining array output data and inverter data will allow for complete system monitoring. Energy inputs, backup KWH, and array KWH, combined with inverter output KWH, will allow comprehensive system monitoring.

For professionals who may need to manage and log multiple SW systems remotely, or users who want a simpler way to program and record system performance, the SWCA and Trace Tools offer a very cost-effective approach. At US$250 for the adapter and the software, the package costs significantly less than most other data collection systems.

A Trace Tools Graph



Access

Don Loweburg, Independent Power Providers (IPP), PO Box 231, North Fork, CA 93643 • 559-877-7080
Fax: 559-877-2980
don.loweburg@homepower.com
www.i2p.org

Xantrex Technology, Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826
Fax: 360-435-2229
inverters@traceengineering.com
www.xantrex.com

California Public Utilities Commission (CPUC), 505 Van Ness Ave., San Francisco, CA 94102 • 800-649-7570 or 415-703-2782 • Fax: 415-703-1758
consumer-affairs@cpuc.ca.gov
www.cpuc.ca.gov

Maui Solar Software, Mike Pelosi, 810 Haiku Rd., #113, Box 1101, Haiku, HI 96708 • 808-876-1859
sales@mauisolarsoftware.com
www.mauisolarsoftware.com

Doing the Best We Can

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

Decisions, decisions, decisions—every day, we make decisions. The decisions each of us makes affect our lives and the lives of others.

Some of us wear helmets when we ride bicycles and motorcycles, and some don't. Many of us choose not to eat meat, while others enjoy a good steak. Some people have life insurance, and others don't. Most wear seat belts in cars, but many do not. Many of us exceed the speed limit, while others adhere to it. Some drive while intoxicated.

The decisions that we make on a daily basis may or may not have consequences—either immediately or at some time in the future. No one can force us to make a particular decision, but we are responsible for the consequences of those decisions. We may be held accountable for them. The same applies to decisions we make when designing, installing, and maintaining a renewable energy system.

In designing and installing a PV system, the longevity of the PV module must be kept in mind. Few engine-driven generators will last more than a few years under continuous use. But PV modules that are being installed today will be producing energy for the next 30 years or more. The first PV cells made in the 1950s are still working, and there is good evidence that the PV module purchased today will still be an energy source in 2050.

With PV systems lasting 30 plus years and generating voltages from about 20 volts to nearly 600 volts, there are consequences of not designing and installing them as well as we can. In residential PV systems, we have to deal with circuits containing high currents at low voltages and high voltages at low currents. On systems above 10 KW, we are dealing with both high voltages and high currents. If these voltages and currents are loosed upon the unsuspecting, they have the very real ability to damage property and harm people, as has been reported in *Home Power* and elsewhere.

Numerous decisions need to be made in designing and installing a PV system. In areas where codes are in effect, the decisions may be spelled out by those requirements. Again, no one is forced to act on those requirements, even when they are the law. Whether in code areas, or in areas where there are no codes, the decisions you make will affect the safety, reliability, durability, and performance of the PV system.

When an individual installs a PV system on his or her own home, the consequences of any decisions might be limited to the home and immediate family members. On the other hand, negative consequences of such an installation where shortcuts have been taken may not be very limited—remember Mrs. O'Leary's cow? (It reportedly kicked over an oil lamp in a barn on October 8, 1871, and the resulting fire burned down a good portion of Chicago.)

When an installation is made for others, the consequences of all decisions may be far reaching. While many *Home Power* readers are technically competent, we cannot assume the same about all "green-minded" people who might buy PV systems.

Doing It Right

For those willing to look and study, the information required to install a safe, reliable, and durable PV system is available. If you are reading *Home Power,* you have the basic sources that you need to get this information.

All previous *Code Corner* columns are available on the Southwest Technology Development Institute (SWTDI) Web site. The *PV Power Systems and the National Electrical Code: Suggested Practices* manual in PDF format is also there. Hard copies are available from Sandia National Labs.

The Sandia Web site also has numerous PV design, installation, and maintenance documents available at no cost. Both the SWTDI and Sandia sites have links to other Web sites with substantial amounts of good information, including U.S. Department of Energy sites. The PV module and equipment manufacturers advertising in *Home Power* have brochures and manuals available for the asking. All of the above materials are free.

The *National Electrical Code (NEC)* and the *NEC Handbook* are available from the National Fire Protection Association and many local electrical supply houses. A Web search will uncover numerous electrical equipment manufacturers that will be glad to provide information on their products. And, if you are unsure about your ability to absorb all of this PV design and installation information, you might want to rely on one of

the experienced PV designers or installers who advertises in *Home Power.*

The *National Electrical Code*

The *NEC* is not legislated into law throughout the entire country. Even in areas where it is in effect, there may be no electrical inspections. However, the *NEC* does present a good set of guidelines for electrical installations, including PV installations.

The code is updated regularly. The requirements that it specifies are, for the most part, based on good common sense and hard facts—hard facts that have been demonstrated by previous property damage or loss of life. Considering the longevity of PV modules as electrical generators, some people consider the *NEC* requirements to be a minimum set of installation guidelines.

You can choose to use listed (tested to the appropriate UL Standard) or unlisted electrical equipment. The *NEC* requires the use of listed equipment that has been examined for safety by an independent, nationally recognized laboratory. The use of listed equipment helps to ensure that the equipment can be installed according to the requirements established by the *NEC.* It also means that the equipment will be compatible with other listed equipment in the system.

Other Decisions

While the *NEC* may assist you in the design and installation of a PV system, many other requirements bear on the design and installation. Building codes may affect both the electrical and mechanical design. Fire codes may impact the location of components.

In nearly every instance where a decision is required in a PV system, there are codes to guide you with additional information to support your decisions. Making the right decisions may not result in the lowest cost system. But it may result in a safer system, a more durable system, a more reliable system, and a system that could yield increased performance over many years.

If you are installing a utility-interactive PV system (grid-connected), any failures in the design or installation (intentional or unintentional) may have far reaching consequences. For example, an improper connection to your household wiring may result in the failure of GFCI devices (ground-fault circuit interrupters). Such failures might not allow these devices to function to prevent electrical shock and death. Following both the code requirements (proper point and method of connection) and using listed equipment will help ensure that unfortunate consequences do not arise when installing a utility-interactive PV system.

The Choice Is Yours

As in all areas of life, you must make decisions when designing and installing a PV system. The consequences of those decisions can be either positive or negative. Only you, the system designer and installer, can make those decisions, and only you may be held accountable for those consequences—both positive and negative. The choice is yours. Study and follow the best guidance available to achieve a safe, reliable PV system. Or don't, and be prepared to accept the consequences if tomorrow or 30 years from now, things don't work out as planned.

An Update

Does the main PV disconnect have to be grouped with the main utility disconnect on a utility-interactive (UI) or combined battery/UI system? Some inspectors, after reviewing *NEC* sections 690.14, 230.2, and 230.70 in the 2002 code, may allow the PV disconnect to be mounted in a location that is not near the main utility disconnect. Of course, appropriate placards must be installed indicating the presence and location of both disconnects. Other inspectors have voiced the opinion that for fire and personnel safety, the two disconnects must be grouped together.

Questions or Comments? If you have questions about the *NEC,* or the implementation of PV systems that follow the requirements of the *NEC,* feel free to call, fax, e-mail, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

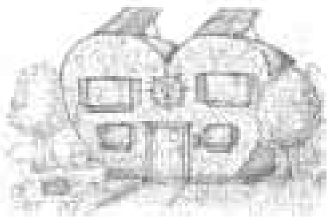
Access

John C. Wiles • Southwest Technology Development Institute, New Mexico State University, Box 30,001/MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105
Fax: 505-646-3841 • jwiles@nmsu.edu
www.nmsu.edu/~tdi/pv.htm

Sponsor: Sandia National Laboratories, Ward Bower, Department 6218, MS 0753, Albuquerque, NM 87185
505-844-5206 • Fax: 505-844-6541
wibower@sandia.gov • www.sandia.gov/pv

The 2002 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Drive, Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301
custserv@nfpa.org • www.nfpa.org

Home & Heart



Kathleen Jarschke-Schultze

I freely admit that I was kicked out of the glee club in the sixth grade because I couldn't carry a tune. I sing only for my family at our annual No Talent Show, for Bob-O, and to my dog. So, with apologies to the Angels, the Chiffons, and all those great girl groups of the Fifties and Sixties...

The Hydro's Back
[Spoken in a soft, breathy voice]

The creek went away and we hung around
And got our power from the wind and sun
And when the clouds came and no rain fell
We knew that things weren't very nice.

[Begin singing to the tune of "My Boyfriend's Back"]

The Hydro's back and we're generating power,
Hey-la, hey-la, the hydro's back
The batteries are charging each and every hour,
Hey-la, hey-la, the hydro's back.

The water's so high we're usin' nozzle number two,
Hey-la, hey-la, the hydro's back
So look out now 'cause the amps are coming through,
Hey-la, hey-la, the hydro's back.

Hey, the creek is finally flowing,
And the turbine's really going.

The creek's been gone for such a long time,
Hey-la, hey-la, the hydro's back
Now it's back and things'll be fine,
Hey-la, hey-la, the hydro's back.

Hey, every day I can do the laundry,
What to turn on next is my only quandary.

What made you think we always needed blue skies?
Aah-ooh, aah-ooh
The wind turbine's quiet now, but our amps are on the rise,
Aah-ooh.
Wait and see!
The Hydro's back, it's gonna save our reputation,
Hey-la, hey-la, the hydro's back
So our Genny DC can take a long vacation,
Hey-la, hey-la, the hydro's back.

Yeah, my hydro's back...

The Drought Has Ended
We had a couple of intermittent inches of rain this fall. Then we had wonderful snow. Right here at Chateau Schultze, we got about six inches (15 cm), and it stayed for a week. Our water year is at normal for this date, and the mountains all around us have visible snowcaps when the clouds clear away.

Our creek started slowly. Then you could begin to hear it whenever you went outdoors. It is a wonderful thing to live around free-flowing water. The water level in the creek rose steadily. After the anemic water flow all last winter, two years' worth of fallen leaves were finally flushed down the creek. We have had to take the walk through the meadow and up the creek to clean the hydro intake many times. This is not a hard job at all. Emma, the Airedale, loves going with us.

Our Hydro
The hydro unit is located in the creek just below our house. We use an Energy Systems & Design Stream Engine. It is about 80 feet (24 m) from our battery bank and power room. Most of the 900 feet (274 m) from the intake to the turbine is 6 inch PVC pipe now. As it nears the turbine, there is 5 inch and some 4 inch PVC pipe.

It used to be all 4 inch and 3 inch pipe when we first started using hydropower in this creek. Every year while the creek is at its lowest (sometimes dry), Bob-O replaces sections of the smaller pipe at the upper end with larger pipe. This has resulted in more power being generated by the turbine.

The head or vertical fall of the water is about 32 feet (9.75 m). That is not going to change by any significant amount. So Bob-O improves what he can, when he can. After the creek had been running awhile, the water level rose enough to allow us to turn on the second nozzle of the turbine. That increased our generated power by 8 amps at 24 VDC, almost doubling the turbine output at the time.

One Saturday, Bob-O built a new, larger base for the hydro unit. That gained us another half an amp. It allows the water to exit the unit more freely through a larger area as it flows back into the creek.

It is wonderful to have the hydro back. Bob-O and I look forward to it every year, and this year especially. The weather the last few years has been kind of wacky, and is getting drier overall.

Electronic Varmint Repeller
I received an e-mail message from a reader, Paul Baxter (a fellow ham radio operator), who had read the sad news that Vermin-X pest repellers (see *HP84* and *HP86*, *H&H*) don't work on modified square wave inverters. He writes, "A solution is at hand however, since Ramsey Electronics sells much the same thing in kit form. The best thing about this model is that it runs on 12 VDC." If any of you get a Rat Blaster Varmint Repeller kit and try it, do let me know how it works.

Tarp Woodshed Update
When the six inches of snow was falling, Bob-O or I had to go out every so often, depending on the rate of snowfall, and clean the snow off the roof of the woodshed. The snow had to be coaxed off the tarp roof. It did not readily slide off.

We cleaned the snow off the roof from the inside by using the long, brush end of a shop push broom. We started by pushing up on the roof about a foot in from the eave to clear that snow. Then we moved the broom up towards the crest of the roof another foot or so and repeated the process.

We found out later that this periodic roof clearing had saved our woodshed. We have some friends nearby who had the same idea of using a tarped canopy for a woodshed. Unfortunately, they were caught on the far side of Siskiyou Summit when the snowstorm hit, and could not get home for several days. The canopy collapsed under the weight of the snow. They came home to a pile of bent steel and torn tarping.

So I will certainly be keeping an eye on my tarp woodshed and the weather till spring. Then one of my first fair weather projects will be to put a metal roof onto the pipe steel roof supports so that the roof can shed itself of snow. The roof has a good pitch—it just needs the right type of roofing material.

I am afraid to actually tally up how many projects I have either going on now or in my mind as having to be done come spring. Part of a birthday poem I once wrote for my sister said:

Keep moving ahead, never look back,
For work ahead, there's never a lack,
Nose to the grindstone, shoulder to the wheel,
We all ante up and take a chance on the deal.

Hey, deal me in.

Access
Kathleen Jarschke-Schultze is starting to dabble in viticulture at her home in Northernmost California, c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com

Energy Systems & Design, Ltd., PO Box 4557, Sussex, NB, Canada E4E 5L7 • 506-433-3151
Fax: 506-433-6151 • hydropow@nbnet.nb.ca
www.microhydropower.com • Stream Engine microhydro generators

Ramsey Electronics, Inc., 793 Canning Parkway, Victor, NY 14564 • 800-446-2295 or 585-924-4560
Fax: 585-924-4886 • help@ramseyelectronics.com
www.ramseykits.com • Rat Blaster Varmint Repeller kit

HAPPENINGS

Send your event info to happs@homepower.com

ENERGY FAIRS
See www.homepower.com/fairs.htm for a list.

INTERNATIONAL
April 2–5, '02; Global Windpower 2002 Conference and Exhibition, CNIT, La Defense, Paris, France. World wide wind industry and commerce event. www.ewea.org/src/gwp.htm

Free instructions, photos, drawings, & specs to build solar cookers & water systems with local materials, purchased with local currency. Sunstove • www.sungravity.com

Green Empowerment finances microhydro & other RE projects in Nicaragua, the Philippines, & Borneo. Volunteers needed. www.greenempowerment.org

Solar On-Line (SõL) Internet courses. Year-round. PV Technology & Opportunities—A Qualitative Overview; PV Systems Design: Basic Course; PV Systems Design: Professional Course; PV System Installation: Hands-On! Solar Homes; Healthy Buildings; & Solar Energy for International Development. SõL, PO Box 217, Carbondale, CO 81623 Fax: 559-751-2001 • info@solenergy.org www.solenergy.org

CANADA
Microhydro Courses '02; Assess site, determine feasibility, & design & install a system. April 26–28: Selkirk College, Nelson, BC, 250-352-6601. May 3–5: College of New Caledonia Prince George, BC, 250-561-5801. May 10–12: Univ. College of Cariboo Kamloops, BC, 250-828-5039. US$80–160. Robert Mathews • 250-679-8589 www.energyalternatives.ca/mhcourse.htm

Alberta Sustainable House; open house 3rd & 4th Saturdays, 1–4 pm. Cold-climate features & products for health, environment, conservation, RE, recycling, efficiency, self-sufficiency, appropriate technology, autonomous & sustainable housing. Free. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 Canada • 403-239-1882 • Fax: 403-547-2671 jdo@ucalgary.ca

The Institute for Bioregional Studies demonstrates & teaches ecologically oriented, scientific, social, & technological achievements. IBS, 393 University Ave., Charlottetown, PEI C1A 4N4 Canada • 902-892-9578

Vancouver Electric Vehicle Association. Call for meeting info. PO Box 3456, 349 West Georgia, Vancouver, BC V6B 3Y4 Canada • 604-878-9500 • info@veva.bc.ca www.veva.bc.ca

WALES
April 5–7, '02; Introduction to RE, University of Wales, Aberystwyth. Overview of RE, small-scale wind, solar electricity, & microhydro for homes, businesses & farms. Info: Green Dragon Energy, 01974 821 564 dragonrg@talk21.com www.greendragonenergy.co.uk/

NATIONAL U.S.
Pollution prevention video series. Appalachia: Science in the Public Interest offers 42 videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar-Powered Automobiles, Quilted Insulated Window Shades, & more. US$25 + S&H, broadcast-quality tapes available. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • Fax: 606-256-2779 aspi@kih.net • www.kih.net/aspi

American Wind Energy Association. Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

State incentives for RE: reports. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 Fax: 919-515-5778 • www.dsireusa.com

Energy Efficiency & Renewable Energy Clearinghouse (EREC): Insulation Basics (FS142), New Earth-Sheltered Houses (FS120), PV: Basic Design Principles & Components (FS231), Cooling Your Home Naturally (FS186), Automatic & Programmable Thermostats (FS215), & Small Wind Energy Systems for the Homeowner (FS135). EREC, PO Box 3048, Merrifield, VA 22116 • 800-363-3732 • TTY: 800-273-2957 energyinfo@delphi.com • www.eren.doe.gov

Ask an Energy Expert: online questions to specialists. Energy Efficiency & Renewable Energy Network (EREN) • 800-363-3732 www.eren.doe.gov

Green Power Web site: deregulation, green electricity, technology, marketing, standards, environmental claims, & national & state policies. Global Environmental Options & CREST • www.green-power.com

National Wind Technology Center. Assists wind turbine designers & manufacturers with development & fine tuning. Golden, CO • 303-384-6900 • Fax: 303-384-6901

Sandia's Stand-Alone PV Systems Web site: design practices, PV safety, technical briefs, battery & inverter testing, www.sandia.gov/pv

Federal Trade Commission free pamphlets: Buying an Energy-Smart Appliance, Energy Guide to Major Home Appliances, & Energy Guide to Home Heating & Cooling. Energy Guide, FTC, Rm 130, 6th St. & Pennsylvania Ave. NW, Washington, DC 20580 • 202-326-2222 • TTY: 202-326-2502 • www.ftc.gov

Solar Curriculum for schools. 6 week science curriculum or individual sessions. Free! 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center • 321-638-1017 www.fsec.ucf.edu

ALABAMA
Centre, AL. The Self-Reliance Institute of NE Alabama seeks people interested in RE, earth-sheltered construction, & other self-reliant topics. SINA, 6585 Co. Rd. 22, Centre, AL 35960

ARIZONA
May 11, '02; 20th Annual Tucson Solar Potluck & Exhibition, Catalina State Park, Tucson, AZ. 9 AM. Bring solar ovens and dish to share. Solar feast, music, solar cooked samples, camping. Info: Bill Cunningham • 520-885-7925 • cuningham@dakotacom.net

Aug. 9–11, '02; SW RE Fair, Northern AZ Univ., Flagstaff, Arizona. In conjunction with the Technical Conference: Sustainable Development with RE Resources (see below). 50 vendors, workshops, keynote guest speakers, exhibits, & demonstrations. Info: Jill Turek, GFEC, 1300 S Milton Rd., #125, Flagstaff, AZ 86001 • 800-595-7658 • 928-779-7658 • Fax: 928-556-0940 www.gfec/swref • swref@gfec.org

Aug. 7–9, '02; Technical Conference: Sustainable Development with Renewable Energy Resources, Northern Arizona Univ. Flagstaff, Arizona. Info: see SWREF above.

April 19–21, '02; AZ RE Expo; Prescott Valley, AZ. For consumers, educators, contractors, youth, & public. Info: Prescott Valley Economic Development Found. • 888-240-4256 www.pvedf.com

June 28–31, '02; PV System Design: On-site Learning Lab, Flagstaff, AZ, Live & learn with PV at the Nature Conservancy's Hart Prairie Reserve, Lodging, camping, & meals available. Info: see Solar On-Line in INTERNATIONAL

Tax credits for solar in AZ. Info: ARI SEIA, 602-258-3422

Scottsdale, AZ. Living with the Sun free lecture series, 3rd Wed. each month, 7–9 PM, City of Scottsdale Urban Design Studio. History & current concepts, design, applications, solar heating & cooling, architecture, landscaping, PV, & cooking. Info: Dan Aiello • 602-952-8192; or AZ Solar Center, www.azsolarcenter.org

ARKANSAS
Sun Life Constr. by Design: Seminars 3rd Sun. of month. Hands-on, incl. ferro-cement & building dwellings for minimal materials expense. Loren Impson, 71 Holistic Hollow,

Mt. Ida, AR 71957 • 870-867-4777
loren@ipa.net • www.Sun4Life.com

CALIFORNIA
Sept. 20–22, ’02; CA Energy Expo 2002, San Diego Convention Center. Latest RE technologies & energy conservation strategies. Info: Richard Brown, 23672 San Vicente Rd., Ste. 363, Ramona, CA 92065 760-653-4022 • rcb@mail2usa.com www.californiaenergyexpo.com

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State University. Ongoing workshops & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551 • ccat@axe.humboldt.edu www.humboldt.edu/~ccat

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm. • 800-555-7794 or 916-654-4058 callcntr@energy.state.ca.us www.consumerenergycenter.org/buydown

Energy Efficiency Building Standards for CA. CA Energy Comm. • 800-772-3300 www.energy.ca.gov/title24

Solar e-Clips, free weekly email newsletter. CA news & info solar energy. To subscribe email with “Subscribe” in subject to: solareclips-request@californiasolarcenter.org

COLORADO
April 7, ’02 Colorado Sustainable Living Roundup, Stapleton, CO. Workshop & technology exhibit. Info: Tom Potter • 800-632-6662 • 303-377-4671 • www.state.co.us/oemc

April 8–9, ’02; Colorado Wind & Distributed Energy: Renewables for Rural Prosperity. Denver Renaissance Hotel, Denver. Educational forum, workshops, & demonstrations; including rural economic development, innovative wind power technologies, biofuels, microturbines, fuel cell technology, solar water pumping, net-metering, energy rates, digester & equipment blending, etc. Info: Tom Potter • 800-632-6662 303-377-4671 • www.state.co.us/oemc

Carbondale, CO. SEI hands-on workshops. PV Design & Installation, Advanced PV, Wind Power, Microhydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Info: Solar Energy International (SEI), PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

May 28–June 1, ’02; Carbondale, CO. Creating Healthy Homes Workshop. Creating healthy, harmonious & sacred living spaces. US$500. Info: see SEI above.

May 28–June 1,’ 02; Denver, CO. Hydrogen Energy Workshop. Basics of hydrogen, hands-on instruction in equipment for production, storage, & use. US$500. Info: see SEI above.

Sept. 9–13, ’ 02; Loveland, CO. Biodiesel Fuel Workshop. Fundamentals of biodiesel, making your own fuel & processor, & convert a diesel engine. US$500. Info: see SEI above.

INDIANA
June 25–27, ’02; PV System Installation, Brookville, IN. Live & learn with PV at Camp Amakanata, Lodging, camping, & meals available. Info: see Solar On-Line in INTERNATIONAL

IOWA
Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. All welcome. Call for schedule changes. IRENEW, PO Box 355, Muscatine, IA 52761 563-288-2552 • irenew@irenew.org www.irenew.org

KENTUCKY
Livingston, KY. Appalachia: Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, more. ASPI, Rt. 5, Box 423, Livingston, KY 40445 Phone/Fax: 606-453-2105 • aspi@kih.net www.kih.net/aspi

MAINE
April 5–6, ’02; Advanced PV seminar. Battery backup, stand-alone, & grid-tie installations. By SolarWinds NorthernLights & Mid Maine Technical College. Info: Flora Stack • 207-453-5014

MASSACHUSETTS
Greenfield Energy Park needs help preserving the historic past, using today’s energy & ideas, & creating a sustainable future. Greenfield Energy Park, NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053 nhazard@nesea.org • www.nesea.org

MICHIGAN
Tillers International, classes in draft animal power, small farming, blacksmithing, & woodworking. 5239 S 24th St., Kalamazoo, MI 49002 • 616-344-3233 • Fax: 616-344-3238 TillersOx@aol.com • www.wmich.edu/tillers

MONTANA
June 3–7, ’02; Biodiesel Fuel Workshop. Lozeau, MT. Includes making your own fuel & processor, & how to convert a diesel engine. US$500. Info: see SEI in COLORADO listings.

July 13, ’02; Sustainability Fair 2002. Rotary Park, Livingston, MT, 9 AM. Over 60 vendors with sustainable goods & services, including RE. Speakers, entertainment, model kitchen, fashion show, children’s activities. Info: Corporation for the Northern Rockies • 406-222-0730 • www.northrock.org info@northrock.org

Whitehall, MT. Sage Mountain Center: one-day seminars & workshops, inexpensive sustainable home building, straw bale constr., log furniture, cordwood constr., PV, more. SMC, 79 Sage Mountain Trail, Whitehall, MT 59759 • Phone/Fax: 406-494-9875 cborton@sagemountain.org

NEVADA
June 15–19, ’02; Solar 2002: Sunrise Sustainability Expo. Reno, NV. Annual American Solar Energy Society conference. ASES, 2400 Central Ave. #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 ases@ases.org • www.ases.org

NEW JERSEY
June 26–29 ’02; The Mid-Atlantic Sustainability Conference: Energy, Buildings, & the Bottom Line. Rutgers University, Newark, NJ. Features the Building Energy 2002 & New Jersey Sustainable Business conferences & two full days of workshops. Info: Jack Kraichnan, NESEA • 413-774-6051 www.nesea.org • jkraichnan@nesea.org

NEW HAMPSHIRE
Spinning a Web of Solar Spirits; workshops on living with the sun. 1st Wed. every month. Sunweaver, 1049 1st, NH Turnpike, NH 03261 603-942-5863 • Fax: 603-942-7730 fonature@tiac.net

NEW YORK
April 1–6, ’02; PV Design & Installation Workshop, Woodstock, NY. Basics of PV, including a hands-on installation. US$550, Lodging & meals available. Info: see SEI in COLORADO listings.

April 27, ’02; North Country Sustainable Energy Fair, Canton Middle School, Canton, NY. Workshops, activities, vendors, exhibitors, presenters, & home tour April 28. Scott Shipley • 315-386-4928 cobbship@northnet.org • www.ncenergy.org

May 10–12, ’02; PV System Installation: On-site Install, Kingston, NY. Learn how to put a home on-line with the sun. Info: see Solar On-Line in INTERNATIONAL

July 26–28, ’02; PV System Installation: On-site install, Chappaqua, NY. Learn how to put a home on-line with the sun. Info: see Solar On-Line in INTERNATIONAL

RE Loan fund: low interest financing: NY Energy $mart Program, NY State Energy R&D Authority • 518-862-1090 x 3315 • Fax: 518-862-1091 • rgw@nyserda.org www.nyserda.org

NORTH CAROLINA
Sept. 9–13, ’02; Celo, NC. PV & Installation Workshop. PV system design, components, site analysis, system sizing, tours, & a hands-on installation. US$550. Info: see SEI in COLORADO listings.

Appalachian State Univ. Solar Energy Society’s free seminars. April 9: PV; April 16: EVs; April 23: Solar Cookers; April 30: Permaculture; May 7: NC Tax Credits. Free workshops each Tuesday night 8:20 pm during the spring & fall semesters, in the auditorium of the Kerr-Scott building, room 17.

Info: Appalachian State University, Boone, NC 28608 • 828-264-4654 • www.asuses.org

Saxapahaw, NC. How to Get Your Solar-Powered Home. seminars 1st Sat. each month. Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 • Fax: 336-376-1809 • solarvil@netpath.net

OREGON

April 5–6, '02; Wind: the Nuts & Bolts, with Robert Preus. La Grande, OR. See EORenew info below, or Oregon Rural Action, PO Box 1231, La Grande, OR 97850 • 541-975-2411 brett@worc.org

July 26–28, '02; SolWest Renewable Energy Fair, John Day, OR. Exhibitors, workshops, Electrathon racing. EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 info@solwest.org • www.solwest.org

SolWest Pre- & post-fair workshops John Day, OR. July 24–25: Solar Water Pump Installation with Windy Dankoff; July 26: Site Survey & System Planning with Larry Elliott; Sept. 21: All-day Solar Cookery Equinox Extravaganza, Seneca, OR. Info: see EORenew above.

Oct. 5, '02; Umpqua Community College's Alternative Energy Fair, Roseburg, OR. Lectures, workshops, exhibits, energy conservation, fuel cells, solar, hydro, wind, & hybrid cars. Fri. Oct. 4th: Dinner forum at Wildlife Safari on overall RE. Fri. at noon: Energy conservation talk in the UCC campus center. Thurs. the 3rd: Tour of nearby landfill energy projects. Info: 541-440-4601 CEWork@umpqua.cc.or.us

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 8 weeks, 4 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 541-942-0302 • apro@efn.org www.efn.org/~apro

RHODE ISLAND

Energy Co-op provides RE, energy efficiency & conservation services, & group purchases of EnergyStar products. Erich Stephens • 401-487-3320 • erich@sventures.com

TENNESSEE

April 22–27, '02; SEI PV Design & Installation Workshop, Summertown, TN, Ecovillage Training Center on The Farm. Hands-on basics of PV. US$550, lodging, camping , & meals available. Info: see SEI in COLORADO listings.

Summertown, TN. Kids to the Country: nature study program for at-risk urban TN children. Sponsors & volunteers welcome. The Farm, Summertown, TN 38483 • 931-964-4391 Fax: 931-964-4394 • ktcfarm@usit.net

TEXAS

Sept. 20–22, '02; 3rd Annual Texas RE Roundup, Green Living, & Sustainability Fair, Fredericksburg, TX. Info: TX Solar Energy Society & the TX Renewable Energy Industries Assoc. • 866-786-3247 Roundup@txses.org www.RenewableEnergyRoundup.com

Nov. 12–15, '02; UPEx'02-The PV Experience Conference & Exhibition. Austin, TX. In conjunction with TX Renewables 2002 & USGBC's Green Building Conference & Exhibition. Info: Julia Judd, Solar Electric Power Association • 202-857-0898 SolarElectricPower@ttcorp.com www.SolarElectricPower.org

El Paso Solar Energy Association bilingual Web site. Info in Spanish on energy & energy saving. www.epsea.org/esp

El Paso Solar Energy Association: meetings 1st Thur. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 epsea@txses.org • www.epsea.org

Houston Renewable Energy Group: meets last Sun. of odd months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 • jferrill@ev1.net www.txses.org/hreg/

VERMONT

PV, Wind, & Solar Hot Water Basics workshops. 1st Sat. each month, April–Sept. Info: VT Solar Engineering, PO Box 697, Burlington VT 05402 • 800-286-1252 • Fax: 802-863-7908 • www.vermontsolar.com

VIRGINIA

Info & services on practical solar energy apps in VA. VA Solar Energy Assoc., the VA Solar Council, & the VA chapter of SEIA. Info: VA Div. of Energy • 804-692-3218

WASHINGTON, DC

April 3–4, '02; 2002 Hydrogen Investment Forum. Marriot Crystal City Hotel, Wash., DC. Info: www.intertechusa.com/Division_Energy/04-02_Hydrogen/2a_introduction.html

April 21–23, '02; Small Fuel Cells for Portable Power Applications international symposium, Wyndham Washington Hotel. Info: The Knowledge Foundation, 18 Webster St., Brookline, MA 02446 • 617-232-7400 Fax: 617-232-9171 custserv@knowledgefoundation.com www.knowledgefoundation.com

WASHINGTON STATE

Oct. 11–13, '02; Intro to RE Workshop, Guemes Island, WA. Intro to solar, wind, & microhydro for home owners. US$200. Fri. evening free & open to public. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 ian.woofenden@homepower.com

Oct. 14–19, '02; PV Design & Installation Workshop. Guemes Island, WA. System design, components, site analysis, system sizing, & a hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 ian.woofenden@homepower.com

Oct. 21–26, '02; Wind Power Workshop with Mick Sagrillo, Guemes Island, WA. Design & install a complete wind-electric system. System sizing, site analysis, safety issues, hardware specification, & hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 ian.woofenden@homepower.com

WISCONSIN

June 21–23, '02; RE & Sustainable Living Fair (a.k.a. MREF), ReNew the Earth Inst., Custer, WI. 120 exhibits & displays, 100+ workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids' Korral, entertainment, keynote speaker. See below for MREA access info.

MREA Workshops: Solar Space Heating, Wind Systems Installation, PV Installation, Straw Bale Construction, Masonry Heaters, Sustainable Living Workshops, RE for the Developing World. Significant others half price. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • Fax: 715-592-6596 mreainfo@wi-net.com • www.the-mrea.org

the Wizard speaks...

What to Do

In today's modern society, environmental protection and energy resources are necessary functions of government. In fact, they complement each other. Considering the state of the global environment and the eventual decrease in hydrocarbon resources, the federal government needs to be directly involved in the production and supply of clean renewable energy. National security and economic stability are also considerations for this endeavor.

Using the resources of the national laboratories, the feds need to first build and operate facilities to produce solar panels, wind machines, and other necessary components of renewable energy systems. Next, the output of these plants needs to be installed on government properties all over the country. The energy produced could then be distributed throughout the U.S. at a reasonable price.

To avoid competition with private industry, these energy devices should not be sold on the open market. Also, the income from the energy produced must be reinvested in more production facilities and installations. This process has an even chance of becoming self-sustaining.

Eventually, it should be possible to transfer the technology to developing nations. This could be done on either a loan or an outright grant basis. If this plan were to be instituted soon, there is a good chance of beating the decline of both the world environment and hydrocarbon resources.

Back Issues of Home Power!

Good Info! Good Deal!
in USA 800-707-6585

Check out our Web site: www.homepower.com
It contains an index of all articles back to issue #1.

You can buy back issues individually *(Shipping included)*:
- $6.25 each for 13 and 16 through 20
- $7.75 each for 21 through 45 (except for 35, 36, 38, 40, 41)
- $8.75 each for 46 through 84 (except for 59–61, 63–67, 79, 81, 82)
- $9.95 each for 85 through current

- OR -

Special Deal: All available back issues for $125, **+ S&H**

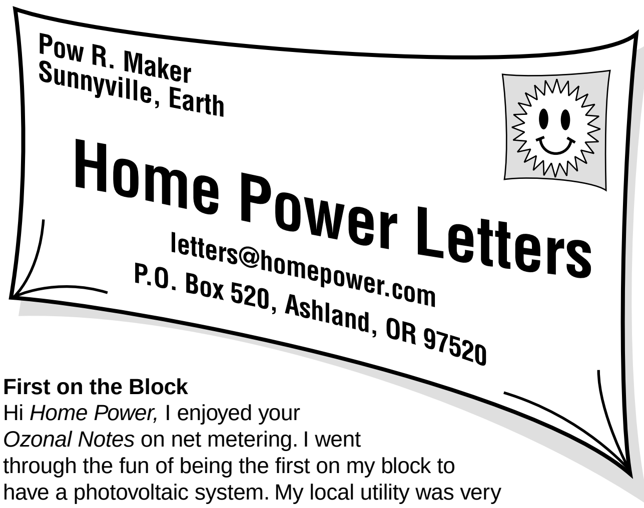
Shipping: $20 USA, $30 Canada, $40 International

Check with your local library—through interlibrary loan you can get back issues.
The Jackson County Library in Oregon and the Alfred Mann Library at Cornell University have all issues.

Or, get the CD-ROMs for $29 each   Special Deal: $125 for all five
Solar2 (1–42), *Solar3* (43–60), *Solar4* (61–70), *Solar5* (71–76), and *Solar6* (77-82)

Shipping for single CDs: $2 USA, $3 Canada, $4 International   *Shipping for all five CDs: $8 USA, $9 Canada, $12 International*

Home Power, PO Box 520, Ashland, OR 97520 • 800-707-6585 • 541-512-0201



First on the Block
Hi *Home Power,* I enjoyed your *Ozonal Notes* on net metering. I went through the fun of being the first on my block to have a photovoltaic system. My local utility was very helpful, to the point of an energy specialist assigned to me taking time off work to help me mount panels on my tracker. They had a basic idea of what I was doing, but it was a learning experience for the meter shop crew, the electrical inspector, the city permit department, city engineers, and the two energy specialists that Tacoma Public Utilities (TPU) here in Tacoma, Washington assigned to me. I think they were concerned that I might blow something up.

I'm sure you'll like this part of my installation. The system is finally finished, I've checked and rechecked all my connections, all PV voltages are right, the tracker is on and tracking, and everything looks like a "go" to flip the switch for the first time and see if this thing is going to work. The folks from the utility said the meter shop people would be out around lunch time. True to their word, Lisa and Justin parked in front of the house at 11:15 AM.

I met them under the array and explained how the tracker works. Then we went to the backyard and the electric meter. They pulled the meter as I stripped the wires from the inverter—all breakers off and fuses pulled—to tap into the line. Wally and Mark, energy specialists at TPU, arrived, as well as two engineers from the city, the chief electrical inspector, one of his men, my brother, and two "shirt and ties" from the utility.

The sun is out, we have sharp shadows, and this is a great day for me to show off my toy. Well, I finish with the wiring, the meter reader reads the meter, and I flip the breakers on. The LED display comes on, and I have 46 watts, 92 watts, 134 watts, the inverter fan comes on, 270, 435, someone says the meter has stopped, 578, 814, 944 watts, and the meter is running backwards for the first time!

Whooping and hollering, high fives by everyone, the dog barking, and the people at the "jack in the crack" behind my house think there's a fight going on so they call the police. Yo, officer, I'm just turning sunlight into electricity for the first time, and we got a little carried away—sorry. (They drove around to the front of the house to see the solar-electric panels and shoot the bull some more.) Richard • SolarRichard@aol.com

Enronomics
Traditional Capitalism: You have two cows. You sell one and buy a bull. Your herd multiplies, and the economy grows. You sell them and retire on the income.

Enron Venture Capitalism: You have two cows. You sell three of them to your publicly listed company, using letters of credit opened by your brother-in-law at the bank, and then execute a debt/equity swap with an associated general offer so that you get all four cows back, with a tax exemption for five cows.

The milk rights of the six cows are transferred via an intermediary to a Cayman Island company secretly owned by the majority shareholder, who sells the rights to all seven cows back to your listed company. The annual report says that the company owns eight cows, with an option on one more.

You sell one cow to buy a new president of the United States from Texas, leaving you with nine cows. No balance sheet is provided with the release of the annual report. The public buys your bull, and you use a small portion of your profits to buy Congress' support for deregulating all transactions involving cows. [Author unknown]

Another Value of RE
Richard, I have read many articles recently, including "The Truth about Payback" in *HP87* regarding the cost and the life cost benefit or loss of RE systems.

It seems that these exposés miss the point and fail to offer one of the most obvious and substantial arguments in favor of RE value. In many cases, RE systems are installed for properties located off the grid. Off-grid properties afford their buyers more desirable, private, and larger real estate for substantially less cost.

While we were searching for our property, it was very apparent that properties served with grid electricity and other services were valued over double what we ended up purchasing. Our property is a beautiful 100 acre piece located on an island that doesn't have grid electricity.

I'm sure that we are ending up with better and more affordable property, saving money enough to install an RE system, and never having to rely on or pay Mr. Sparkey for ever and ever. Joe Schley, Lasqueti Island, BC, Canada

California RE Permit Saga
Dear *Home Power,* I live in the city of Los Banos, Merced County, California. We are very concerned with California's energy problems, so much that we purchased a 1 KW hybrid system (Air 403 wind turbine and PV). We have been trying to get a permit for both systems, but after 2.5 months of waiting to see if they will allow the wind turbine to be put up, we decided to get a permit just for the PVs.

During the process of getting the permit, Greg Johnsen, the senior building inspector, told me that they had sent me a letter and phoned me months ago with their decision. I told him that I have not received a letter or phone call from them, and that I would come pick it up. When I got there and asked for the copy, they told me to come back in an hour and a half and it would be ready then.

Michael Holland, the senior planner decided that wind turbines (size, smaller than a TV antenna) where not allowed, because the city code did not state yes or no regarding wind turbines. He told me that I could appeal the decision for US$150, but from speaking to the department, they all felt the same and the outcome would most likely be the same. He suggested that I wait, the city of Los Banos would be having a city planning meeting to discuss the changes in the city and building codes. During the public forum, I could request a zone change to allow wind turbines.

I tried to make an appointment with the mayor to discuss his views on renewable energy; instead I received a not so friendly call from Steve Rath, the city manager. He stated that as Michael had written in the letter, "No wind turbines are allowed within city limits." After receiving that call, I understood that the city wanted me to drop the issue. Unfortunately for them, I wasn't about to do that, and I started making phone calls.

Getting our PV permit was no easy task either. We supplied them with all the usual items. They then requested a letter from PG&E

stating that PG&E will allow us to put solar-electric panels on our home. After receiving this request, I thought for sure the city had it in for us. I truly thought that we were on some sort of blackball list. They told me that the only thing holding up my permit was the letter from PG&E.

I thought everyone knew about the "Solar Rights Act," but I didn't want to argue about it. I called David Ore, PG&E's E-Net program manager and told him about the request. I told him it was the only thing holding up the permit, and asked if he could do me a favor and write a letter for me. He asked me if they knew about the "Solar Rights Act." I told him that I knew it was a crazy request, but I had to get a letter. He agreed, but stated that it was not customary for PG&E to write such a letter. His letter states that under CPUC code 2827, AB 29 the customer does not require permission before placing solar-electric panels on their home.

I submitted the letter, and asked when I could pick up the permit. I was told that the letter would be reviewed and the permit would be ready the following day. That was perfect. It was Columbus Day weekend, and I called our friends and set it all up for them to help install the system that weekend. I went in to pick up the permit and was told that Grey Johnsen, the senior building inspector, wanted to speak to PG&E, and that the fire chief needed to inspect our batteries. After all this was done, *then* I would get my permit. I called and canceled the install and told our friends that I would let them know when it was going to happen.

On the following Monday, the fire chief, Chet Guintini, and captain, Tim Marrison, came out to the house and inspected the batteries. After that was done, the fire chief asked if we were the ones with the wind turbine. We asked if they wanted to see it. They agreed. My husband picks up this small box and the chief and captain looked at each other and said, "That's it?" They both looked surprised by the size of the box and even at the size of the turbine.

The fire chief said that they had heard about our request and didn't know what to do about it and just hoped it would go away. He told me that I should have brought it in for them to see. That it might have impacted the end decisions. I told him that I tried, but no one was interested. The chief told me I should bring it down at the next council meeting so that everyone could see it. I told him that I would think about it. After the chief left, I went down to city hall to pick up the permit.

When I got there, there was buzz about the wind turbine. I was told that the fire chief came in and was very impressed with our turbine and had mentioned how small it was. I asked if they had spoken to PG&E and I was told no, but that the request was waived. I finally got my PV permit...

At a Wednesday, Oct. 17th city council meeting, I spoke about how California has set up incentives, and Governor Gray Davis signed the bill that gives us a 15 percent state tax credit, and how for about US$1,800, an average home of three bedrooms can produce up to 50 percent of its energy use. All this to get more Californians involved during the state of emergency that California faces today.

Now, all that Los Banos residents can do is keep asking "When?" When is the city of Los Banos going to join the rest of California in "Flexing Our Power?" Yuly Springer, Los Banos, California • wp400watts@yahoo.com

Hi Yuly, With all those people trying to control the lives of you and your neighbors, it's a wonder anything gets accomplished. It's also not surprising that we have lots of guerrillas of various sorts in our supposedly "free" country. Your determination in the face of all that bureaucracy is inspiring! Ian Woofenden ian.woofenden@homepower.com

Hello Yuly, I pretty much agree with Ian, but allow me to point out that you have done a wonderful service in your efforts—educating those that needed it the most. The Los Banos officials obviously did not have a clue about RE. Who can blame them, after years of listening to utilities and oil industries falsely tell the world that RE doesn't work. And the epiphany of finding out exactly what that wind machine really looked like must have been a sight to behold. No doubt they had fears of your yard ending up looking like it contained a commercial wind machine behemoth ala nearby Altamont Pass. Surely, any community needs protecting from that kind of development downtown. Good work, and keep on fighting the RE fight. Michael Welch • michael.welch@homepower.com

Entrenched Power Structure

Dear *Home Power,* Over the last sixteen years, I have built my renewable energy business from scratch. Any of you that have been around as long as I have know the sacrifices we have made and how hard we worked.

Last week, I was ordered by my doctor not to do anything because of a back strain, so the arrival of the latest *Home Power* was welcome. The letter from Paul Thompson titled "Calling all Canadians" lit my fuse. He wants to create an organization to lobby politicians to promote solar energy. We have been on this merry-go-round for twenty years. I paid memberships to every organization I thought could help. I even served on the board of directors for two of these groups. We worked hard and many still are at it today. So why are we not making much progress?

The scientists are warning the politicians of the danger of their inaction. We are saying, "Look, we have solutions to your problems." I know they hear us, and yet nothing significant is happening.

The problem all comes down to how our political system works. Governments of all political stripes get their resources from taxation. The most stable taxes come from things we do over and over again like the purchase of energy. If every Tom, Dick, and Harry starts making their own energy, an important source of revenue will begin to shrink. There goes the money they want to spend on the pre-election goodies that get them elected. And you want the government to help you buy solar stuff?

Speaking of elections, where do you suppose most of the contributions to run their campaign comes from? There is more than oil and gas involved. These are the rich and powerful who intend to stay that way. What politician in their right mind would say or do anything to risk damaging or even upsetting these people?

People like to associate with people of similar status. Tradespeople with other tradespeople, professionals with other professionals, and the rich and powerful with the just plain powerful. Unlike middle and lower class people, their pool of friends is a very small and close-knit group. They could find themselves very lonely if several of the group became upset with their actions. And you want the government to help you buy solar stuff?

OK, just make the utilities buy our excess electricity. Give us free access to the grid. What a ridiculous idea. Imagine going to work on Monday morning and being told that someone else is going to do your work and you must pay them. You would go crazy, and you would have a thousand excuses why this should not happen. And I bet you would make this person's life hell, even if they were there with good intentions.

So why does the government keep leading us along? Wouldn't it be simpler just to say "No, not allowed, illegal," and forget it? I dare them! I double dog dare them. Talk about guerilla solar—this would be the biggest backfire since the government outlawed alcohol in the 1930s.

The general public believes in renewable energy. They know that nuclear energy is not safe, and that burning all this oil and gas is not good. They are watching and listening to what is going on, but the message they are getting is that solar energy is too expensive, it is going to be really cheap in the future, or maybe the fuel cell is a better idea. Where is this message coming from? Could it be from our government? I wonder why? If you wanted to stop people from buying cars this year, just tell them that next year's model will have twice the power at half the price.

It's obvious from the takeovers in our industry that someone has seen the writing on the wall. They have used their political clout, and tried every trick in the book to stop this movement or at least slow it down until they figure out how to control it.

We are one stubborn bunch of old dogs, and we won't give up or go away. That's because this life is our passion. Yes, we want to make a living, but more important, we are helping others take control of their lives and do what is right for our future. We all like solving problems, and this is going to be a big one.

The politicians are caught between a rock and a hard place. If they support renewables, they lose their support from the rich and powerful. If they openly try to block our progress, they will lose the support of the general public. If we allow the politicians to continue this deception, we are all going to lose our environment.

I hope this gets a little discussion going among people who like to fix things. Can a solution be found where everyone wins? Regards, Laurence McKay, Northern Lights Energy Systems, Ltd. • 705-246-2073 • northern.lights@sympatico.ca

***HP* Schematic Art**

You folks always have such great diagrams of various RE configurations, such as the one on page 15 of *HP86*. I wondered what tool you use to create these RE system drawings. I would like to do a better job documenting my own system, and an automated tool would help. Have you ever thought about selling your RE component images? Thanks for continuing to do such a great job on your magazine. Sincerely, John Jencks

Hi John, The system schematic drawings in Home Power *are created with Postscript illustration software. There are several viable programs from various companies.* Home Power *uses Freehand by Macromedia. Others are Adobe Illustrator and CorelDraw.*

Be aware that these are merely drawing programs. There is no connection to the electrical aspects of the drawings we make—these are not electronics CAD programs. Also, all of the components that you see in Home Power *were drawn from scratch. There is no ready-made library of renewable energy system components.*

These programs are quite versatile and powerful. But this makes for a steep learning curve. Once you get it though, the possibilities are vast. Of course we're flattered by your inquiry about purchasing our art, but we've made a pact signed in blood to never sell our schematic components. Good luck, Eric Grisen and Ben Root eric.grisen@homepower.com and ben.root@homepower.com

Renewables for National Security

Richard, Congressman Elton Gallegly is a conservative Republican. As it happens, he posed the following question in a survey contained in his November 2001 newsletter to his constituents, which I received two days ago:

> Do you favor increasing or oppose increasing federal subsidies for alternative energy sources, such as solar, wind, and fuel cells?

I filled out the survey on-line today, and included the following screed in the remarks section provided. I hope it will be of some slight interest to you, and possibly to the readers of *Home Power* magazine.

> Dear Congressman Gallegly, I am a longtime Republican who has voted for you since your first congressional campaign. I am also a military veteran who holds the Navy Expeditionary Medal for service in Lebanon in 1983. I was one of those who brought dead U.S. marines out of Beirut after terrorists destroyed the marine barracks at the Beirut airport on Sunday, 23 Oct. 1983. There are times I still have nightmares about it. I know the face of terror firsthand.
>
> With that having been said, I wish to share some of my thoughts with you, if you can find the time in your busy schedule to read them. With reference to defending ourselves from terrorist attacks upon our electrical infrastructure:
>
> 1) Decentralizing our electrical power production hardens our electrical power infrastructure against terrorist attack.
>
> 2) Maximum hardening can be accomplished by spreading our production of electricity out as widely as possible. Ideally, every homeowner should own the means to produce most or all of the electricity consumed in his or her home.
>
> 3) What caused a major part of the so-called electricity crisis in California this summer was not a lack of enough electrical energy, but rather our inability to transport it between states. Indeed, transmission line losses sap about 15 percent of the energy produced. The shortfall in California was usually less than 3 percent, and never got anywhere near 15 percent.
>
> 4) The same thing would most likely be true in the event of a terrorist attack on our electrical power plants and/or electrical transmission lines; we'd have enough energy, but not at the right places at the right time.
>
> 5) Had that 3 percent of the total electrical energy that California needed so desperately been produced at the points of consumption, there would have been no problem, and no crisis. A few billions of dollars spent before the crisis on prevention would have avoided a few tens of billions of dollars spent this year and in the years to come on the cure.
>
> 6) High voltage power transmission lines are extremely vulnerable to terrorist attack. So are large electrical power plants.
>
> 7) Rooftop photovoltaic (PV) systems are not vulnerable. PV arrays are therefore a vital part of our civil defense against Osama bin Laden and those who would ape his vile, hate-driven actions against the civilized world.
>
> 8) Solar electricity produced via photovoltaic panels is the best technology we have at hand to harden our electrical distribution infrastructure by dispersing it.
>
> 9) PV has at least five major side benefits for Californians:
>
> a) It is green energy. We have a major problem here in California with greenhouse gases. PV is part of the solution.
>
> b) PV produces the most electricity when California needs the most electricity; on hot summer days.
>
> c) Rooftop PV arrays lessen the amount of electrical energy needed for air conditioning, because much of the roof is shielded from the sun by the PV panels themselves.

d) Decentralized power production harks back to Jefferson's concept of the semi-independent yeoman farmer who produces much of what he consumes. Why increase the size of government when we can get the same or better results by offering tax incentives for people to put PV panels on their roofs?

e) Producing and installing PV will help create new jobs without increasing the size of the federal bureaucracy. Thus, we can do well by doing good.

10) We are largely at the mercy of oil-producing countries. We can significantly change the calculus of this by aggressively pushing PV panels as a strategic natural resource that is a necessary and vital part of our national defense.

11) The best time to have begun was years ago.

12) The next best time is now.

13) Siemens Solar, in our congressional district, produces roughly 20 percent of the world's PV panels. About 75 percent of what they produce is exported. Thus, we have right at hand the tools we need to begin hardening our electrical infrastructure.

14) Hardening this infrastructure cannot be done overnight; we must put the tools in place and keep them there if we are to succeed. This means no on-again, off-again federal PV subsidies. Do it right the first time, and then don't monkey with it.

12) We can help to provide for the common defense, promote domestic tranquility, and secure the blessings of liberty to ourselves and to our posterity by putting solar-electric panels on every rooftop in California.

13) Of course, we can opt to do nothing. But remember, we can pay billions of dollars now for prevention, or tens of billions of dollars later on the cure.

Thank you for your kind attention to my letter. May God uphold you and give you the wisdom and strength you need now and will need in the years to come to best serve our country and uphold our Constitution.

Wishing you and yours the very best, I remain...Rodger Morris morris_rl@yahoo.com

Guerrilla Flak Catching

Dear *Home Power,* I was disappointed by the letter in *HP86* that was critical of the guerrilla solar system in *HP85,* and the "conduit meister's" response. *HP86* also showed a guerrilla solar system with the MicroSine inverter wired to a male plug for connection with a receptacle. I'm sure it would garner the same kind of undeserved criticism.

Mr. Meads writes that "a licensed electrician knows that you do not ever wire cords so that the male cord cap is energized." This kind of thinking may be the greatest problem that the PV industry faces. Licensed electricians and the officials who enforce, update, and monitor the *NEC* and local codes are well trained professionals. Unfortunately their training in household and industrial power distribution systems does not necessarily equip them with expertise in all power systems (including distributed generation and PV).

Most people would agree with Mr. Meads' comments without first stopping to consider the reason for them. The *NEC* was originally written to promote safety from shock and fire hazards. Article 110-27 specifies that "live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact…" This implicitly defines 50 volts as the hazardous shock level we need to avoid. In the *HP85* guerrilla solar system, the panels are wired for 24 volts. In the general case (not these specific Photowatt panels) they would have an STC open circuit voltage in the 40 to 42 volt range. Using the cold temperature multipliers in Table 690-7 shows that in the coldest parts of the country, some types of panels will exceed the 50 volt limit. This is just one of the ridiculous aspects of article 690. Whether 52 volts is much more hazardous than the 50 volts is open for debate, but the *NEC* is clear—this system is safe from voltage hazard in the southern climate where it is used, but hazardous (and requires guarding) in the northern states.

There are real problems with this system. Plugs and receptacles should never be used on power systems for which they are not intended. It could be a hazard if someone plugged an AC appliance into the receptacle with DC power present. The panel cord appears discolored indicating possible UV degradation. One of the cords from the receptacle to the charge controller in the house appears to be standard household wiring. It is neither flexible enough, nor covered with appropriate insulation for the outdoor exposure or routing through a dryer duct. It is likely not heavy enough to handle the rated maximum power point current or the short circuit current as required by the code. Unfortunately, the real issues are not normally discussed. The automatic reaction is to condemn the system for the wrong reasons.

If we consider the guerrilla solar system in *HP86,* many people would use the discussion above to argue that it is unsafe due to hazardous voltages (120 VAC). A more thorough analysis would conclude that the utility interconnected inverter does not present a voltage to the plug if it is not connected to the utility. If it is plugged in, it is no more hazardous than any other AC appliance that uses the same type of plug. In many parts of the world it would not be considered a hazard. We could discuss the need for a dedicated branch circuit breaker identified for backfeed, as specified in Article 690, but that tirade is a different letter. Patrick Cusack, Arise Technologies Corporation, Kitchener, Ontario, Canada

Hello Patrick, Thanks for your response. I agree with Larry Meads' statement in the Letters section of HP86: *"Do not ever wire cords so that the male cord cap is energized." We printed a safety note in* HP86, *page 142 about this. The guerrilla solar article in* HP85 *used this wiring method multiple times.*

The PV side of this system operates at 24 VDC nominal (the controller down-converts to 12 VDC). The exposed male cord caps on the PV side of the controller do not present a shock hazard due to the low voltages involved. But the use of male cord caps here could potentially result in damage to the PVs. If one of the cord caps was stepped on when it was unplugged, a potential nonfused short between the PVs' positive and negative leads could result (the 60 amp PV output fuse would be isolated from the PVs in this case and not open the circuit.) If the PVs were operated for an extended period in this shorted condition, damage to the PVs would most likely result.

Energized male cord caps are present in three places on the AC side of the inverter in this system. Two occur in the male to male cord used to interface the inverter output via the Brand meter and the 120 VAC wall receptacle. The third is the male cord cap hardwired to the Brand meter.

If the male cord cap was unplugged from the 120 VAC wall receptacle, no grid presence would be sensed by the inverter, and AC output would cease within milliseconds. No shock hazard would exist, since the cord cap is wired to the AC 1 (grid input/grid synchronized inverter output) inverter terminals. This scenario, like your above reference to a MicroSine wired with a male cord cap, does not pose a shock hazard when unplugged. Interrupting inverter output when no grid electricity is present is exactly what both inverters are designed and certified by UL to do.

But a serious shock hazard would exist if the male to male cord was unplugged from the Brand meter or the Brand meter was unplugged from the receptacle hardwired to the inverter's AC 1 terminals. In this case, the grid would continue to energize the cord cap or caps. I suspect that these are the connections that Larry was correctly concerned with. Too bad the grid's not as smart as the inverter! Thanks for taking the time to write. Joe Schwartz joe.schwartz@homepower.com

Watch Out for Those Knowledgeable Sources
Hi, I have heard from a couple knowledgeable (?) sources that photovoltaic cells are not really that money or energy efficient. The problem, as it was explained to me, is that the electricity required to manufacture a cell is almost as great as the expected output of the cell over its life. I was told that these cells just pay for themselves over the useful life of the cell, with little return on investment. Is it more efficient to use solar energy as thermal energy rather than converting it to electricity? Thank you Karl Wilkinson

Hi Karl, Your sources are less than knowledgeable. PVs recoup their energy investment in 2 to 4 years. Most modern panels have 20 to 25 year warranties, and we expect them to last 30 to 40 years or more. We ran an article on this subject in HP80. *Solar-electricity* looks *expensive because nonrenewable energy is so heavily subsidized. Solar thermal energy is more cost effective, and a great idea. But it won't run your lights and stereo. Ian Woofenden ian.woofenden@homepower.com*

Magnetic DC Generators
I charge my batteries with a 30 amp (at 24 V) alternator powered by a 6 hp motor, with the charge controlled by a rheostat. I recently upgraded my battery bank to eight, 350 AH Trojans wired for 24 V. I would like to increase my charging capabilities. I am considering a 50 amp alternator in place of the 30. How many watts (or amps at 24 V) can I expect out of a 6 hp motor? Will it push this much power? Could I use a more efficient magnetic alternator as featured in some wind turbines? Would the magnetic alternator require a rheostat, and wouldn't it produce more amps per horsepower? Jeremy, Tonasket, Washington

Hello Jeremy, Your 6 hp engine should easily drive the 1,450 watt (50 amps times 29 volts) alternator if the engine is in good condition. Be sure to use a gear-up pulley on the engine. In my experience, a 6 inch diameter pulley perfectly matches the stock pulley on the alternator. With the proper pulley ratio, your engine should deliver 50 amps at 29 VDC from the alternator.

The alternators used in wind generators are the permanent magnet type. The rheostat scheme you are now using will not work on them. Stick with the automotive alternator—they are far better suited for use with an engine. Driving the electromagnetic field of the automotive alternator only draws around 30 watts. Richard Perez richard.perez@homepower.com

Dissecting the Belly of the Beast
On page 54 of the Feb/March 2002 issue of *HP*, Mr. Udall states that one pound of coal will produce 2 pounds of carbon dioxide. This understates what is probably produced. Assuming that coal is pure carbon and that complete combustion is achieved (no unburned C, no carbon monoxide), CO_2 will be produced according to this equation:

$$C + O_2 \rightarrow CO_2$$

So for every C atom, a molecule of CO_2 is produced. C and O have different atomic masses; carbon's is 12 and oxygen's is 16 (see the Periodic Table). So the weight of CO_2 produced will be the same proportion as the ratio of the mass of CO_2 to C. That ratio is $^{44}/_{12}$ (the mass of CO_2 divided by the mass of C). So 1 pound of C will produce 1 times $^{44}/_{12}$ lbs of CO_2 or 3 $^2/_3$ pounds of CO_2.

Realistically, coal is not pure carbon, and complete combustion is not achieved, so the actual amount will be less (but probably more than 2 pounds). Coal contains varying amounts of sulfur, and SO_2 would also be produced, which is a contributor to acid rain.

I found Mr. Udall's article very informative—his message must be kept before the public if any headway is to be made with respect to the impending end to our finite supply of fossil fuel. I am fond of pointing out to my students that virtually every manmade object in their daily lives is derived from oil, and the largest use we make of this precious resource is simply to burn it! Regards, Paul E. Vorndam, PhD, Professor and Chair, Department of Chemistry, University of Southern Colorado, Pueblo, Colorado

Mr. Vorndam is correct. When you burn a pound of coal, you produce at least *2 pounds of carbon dioxide, as carbon in the coal combines with oxygen in the air. Two pounds is a handy approximation. The actual number tends to be about 2.2 pounds, or one kilogram.*

In concert with James Watt's invention of the steam engine, coal changed the world, and now is changing its climate. Industrial mining of coal, an activity which seems so retro and mundane today, had a revolutionary impact on human civilization.

The 19th century poet Ralph Waldo Emerson, who witnessed it first hand, wrote, "Coal is a portable climate. It carries the heat of the tropics to Labrador, and it is the means of transporting itself wherever it is wanted. James Watt whispered in the ear of mankind his secret, that a half-ounce of coal will draw two tons a mile, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta, and with its comfort brings industrial power."

More than twenty new coal-fired power plants have been proposed for the U.S. in the last year. Most of them won't get built, but coal's abundance will remain a double-edged sword for decades to come. Randy Udall

Protecting PVs from Flying Objects
Dear Richard, I was a regular subscriber to your magazine when I was in the Middle East. Since my move up to Asia, I find your magazine regularly in the bookstore.

I would like your advice regarding photovoltaic modules mounted in my home, which is on Basilan Island in the south of the Philippines. Because there are some stray flying objects, such as stones, wood, etc. that might end up hitting the solar-electric panels, I am considering mounting safety glass over them. I wonder whether this will affect the efficiency and reduce the lifetime of the PVs. Thanks, and more power and success to your endeavour. Regards, JB

Hello JB, Putting another layer of glass in front of the PVs will decrease their performance. The extent of the decrease will depend on the type of glass. Safety glass will decrease performance by around 15 to 20 percent. The glass used to cover PVs is a special type of low-iron glass commonly called "milk glass." The low-iron glass absorbs less of the ultraviolet radiation, which is what the PVs use to make electricity. The glass traps these photons and turns them into heat. Low-iron glass absorbs less of the upper frequencies of visible light and near ultraviolet light, so it passes more of these useful photons to the PV cells. So if you must cover the PVs with additional glass, use low-iron glass.

While additional glazing will raise the PVs' temperature somewhat, I doubt that this will shorten their life. But I doubt that adding more glass is necessary. The glass already covering the PV module is incredibly tough stuff, and designed to resist impact from large hail stones. I'd trust to luck, and mount the PVs high enough to avoid debris. Richard Perez • richard.perez@homepower.com

A Third Possibility
Dear Editor, In your recent article "Wrenches vs. Dot Commers" (*Ozonal Notes, HP87*), you talked about two choices of installing an alternative energy system—either hire a professional for everything or do it yourself. There is a third choice I have employed almost exclusively for twenty years. That choice is to strongly encourage homeowners to assist in the installation. Most independent Montanans are eager to participate.

The advantages for the customers working with the installer include a reduced price and a hands-on education about how the system works. As an installer, I enjoy the teaching aspect of bringing a novice up to speed on alternative energy, and end up with a much more educated and self-sufficient individual. Steve Hicks, Mountain Pass Wind, White Sulphur Springs, Montana

Wrench Alternative Theory
Dear *Home Power,* We are wrenches in the conventional sense. We sell and assemble pre-engineered metal building kits. Granted, it is not as complicated as a PV system on a per man-hour basis, but I don't turn a customer away because he got ripped off by a salesman who only wants to get product delivered and a check in his hand. I give these people a fair price that I can make money at.

Often times, there is a lot of extra cutting, welding, and fitting, which requires technical expertise that very few homeowners possess. I actually feel sorry for these people. They just got schnookered out of a large sum a money by buying a "sale" building out of the paper. It wasn't a good deal at all, and they have a pile of stuff that is pretty worthless to them if not assembled. Proper assembly makes it worth even more, since no one likes a leaky roof.

Ninety-nine percent of the time, after they watch you put it together and you show them what was wrong and what you had to do to make it right, they are really thankful and you will gain their trust. If they need help, they will turn to you. We have a repeat customer we have done US$2+ million worth of business with over the last ten years, because he looked like he was having trouble, and we stopped by to see if we could help. If you can't make money this way, either your expertise is not good enough or your pricing schedule is wrong.

Of course, we prefer selling the right system in the first place, and not picking up after others' mistakes. The reality, though, is that somebody is always getting a "deal" somewhere that usually costs more due to the extra work required to install it. And someone will try to install it. Whether you as a professional decide to or not is your call, but whining about it won't help any. If the client isn't financially overextended, an installer can make good money and get a repeat customer that is more loyal than most. My boss Dave calls it, "educatin' the world," and we realize it will never end. Steve

12, 24, or 48?
Hi Richard and crew, Here is a quick thought on the question of what system voltage to choose for a home. On the Solar Home Tour, we met four nice families, two of which shut down their inverters every night. I intend to do the same once we are off grid. This means that the refrigerator will be DC, and that the requirements of the refrigerator define the system DC voltage. 12 and 24 volt refrigerators are common. I have yet to see one for 48 volts. Pete Gruendeman • gruendeman@worldnet.att.net

Hello Pete, I don't know of any 48 volt DC refrigerators. Our new DC refrigerators do run on either 12 or 24 VDC, but not 48 VDC. However, Solar Converters makes a highly efficient 48 volt to 24 volt converter that will run a Sun Frost DC refrigerator. The converters are typically more efficient than an inverter. Let me know if you wish to discuss this any further. Larry Schlussler, Sun Frost info@sunfrost.com

Hello Pete, Check out the sidebar in HP87, *page 39 for an overview of choosing your system voltage.*

Most homes, even off-grid ones, have at least a couple of appliances that run 24/7. These days, the most common offenders are cordless phone base stations. As a result, it's more common for inverters to be up and running all the time rather than going into search mode, or requiring nightly inverter shut downs. You need to make the same decision between system efficiency and convenience that all folks with off-grid systems need to make.

For example, a Trace SW series inverter in search mode draws only a watt or two. At idle, Home Power's *SW4024 draws 18 watts. If we estimate a potential nightly inverter down time of ten hours, the SW4024 inverter would consume approximately 15 WH of energy in search mode. At idle it would consume about 180 WH of energy overnight while powering your cordless phone base station. If we estimate an overall system efficiency based on PV rated watts of 60 percent, the inverter at idle would very roughly consume the daily output of a 75 watt PV module. The decision you have to make is whether the cost of adding an additional module to your system is worth the convenience you'll gain, year after year. You also need to consider what other appliances you want to run.*

Sun Frost refrigerator/freezers are the most efficient units out there. They are not available in 48 VDC. There have also been great improvements in mainstream AC refrigerators/freezers in the last year. Check out www.energystar.gov for a comparison of energy efficient AC units. Joe Schwartz • joe.schwartz@homepower.com

A Right to Foreign Energy?
I was glancing through your magazine at the newsstand today and starting reading "The Diet of the Beast." There's a statement to the effect that perhaps Canada will start to cap its exports of gas to the U.S. According to the North American Free Trade Agreement, Canada has to treat the U.S. the same as its own citizens, and cannot limit its exports. In fact, the U.S. has greater reserves than Canada because as soon as the U.S. uses some of its reserves, they are backfilled from Canada. That's why Clinton had no trouble releasing some of the U.S. reserves during a winter shortage two to three years ago. The effect is that Canada has no reserves. Several years ago, in a report about energy supply, the U.S. Congress asserted that the U.S. has a *right* to Canadian gas and oil. Imagine, one country saying it has a right to another country's resources. Brian Freemantle, Prince George, BC, Canada

Plenty of Water?
Dear Mr. Wizard, Regarding your comments in the article "The Water Barrier" in *HP87,* perhaps the following quote from "Solar Hydrogen: Moving Beyond Fossil Fuels," by Ogden and Williams (World Resources Institute, 1989; p. 45 & 48) may be of interest:

> ...the consumptive water requirements of electrolysis are a modest 63 liters per GJ of hydrogen produced (assuming the water used to cool the electrolyzer [or the CPV] is recirculated). In producing an amount of hydrogen equivalent in energy to one liter of gasoline, only two liters of water are consumed. For comparison, per capita water use in the U.S. is more than 100 times the per capita level of petroleum consumption (in volumetric terms). Thus, the water requirement for enough hydrogen to replace current petroleum use would be a 'drop in the bucket', adding only about 2 percent to the average per capita water use in the United States.
>
> Water requirements are also quite modest compared to precipitation levels in areas where PV hydrogen systems might be located. A typical average insolation value for hot arid regions is some 270 watts per square meter. If the land area

requirements were twice the PV collector area (to prevent shading), the water requirements for hydrogen production would be some 2 to 3 centimeters per year, a small fraction of total precipitation even in very arid regions. Consequently, PV hydrogen can be produced even in deserts. For example, even though El Paso is in one of the driest areas in the United States, with annual rainfall amounting to only 20 centimeters (8 inches), the water required for electrolysis is only 12 to 17 percent of the total precipitation falling on the PV collector field.

Ogden and Williams' 1990 calculations assume 15 percent efficient PV and 85 percent efficient electrolyzers. With today's multijunction concentrator PV, at twice the efficiency as that in the Ogden and Williams' assumption, the land area calculation for a given electrical output would, of course, be much less. Joe Reid

Hi Joe, If your figures are correct, there may not be a problem with water usage for petroleum replacement. However, there still may be problems if hydrogen is also to be used as a backup and nighttime source for electricity production, and for heating and cooking. In many parts of the world, water is even now in short supply. These areas may not be able to handle more demands on already limited water resources.

There are other potential problems with things such as increased atmospheric water vapor from hydrogen burning, and increased atmospheric oxygen content from hydrogen storage. We should, of course, still go on toward a total hydrogen energy economy. We must, however, carefully monitor the process for potential pitfalls, so early solutions can be implemented if necessary. Thanks, the Wizard

Are Energy Storage Rods Hazardous?
Hello, I'm a hazardous waste coordinator in Minnesota. Recently, I received fourteen "energy storage rods" at our county HHW facility. They contain a liquid/solid material inside. From my understanding of how these rods work, the material is liquid when warm and semi-solid when cool. The markings on these tubes are: "Energy Storage Rod Thermol 81® P.S.I Energy Systems, Inc. St. Louis, MO Registration #6743."

What I'm looking for is any information on this "Thermol 81" and what it is made of. I would rather not have to crack open one of these tubes to test this substance. If you have any information or can point me in the right direction to find info, I would greatly appreciate it. Thank you, Paul Pieper, Hazardous Waste Coordinator, Rice County Solid Waste Department • 507-332-6833 Fax: 507-332-0530 • wasteco@co.rice.mn.us

Hi Paul, Thermol 81 tubes contain calcium chloride hexahydrate. You would know better than we about this material's hazard. Don't eat it. Unless these tubes are cracked or leaking, they may still be useful. They are basically a phase change material designed to store thermal energy, probably originally used in a solar home. They should melt at approx 81°F. Since this is a phase change technology, a significant amount of energy will probably have to be added at that temperature to see the change.

My suggestion is to test them, or at least one of them. Heat them to 81°F and hold them there until they melt. Then, they should give off heat (at 81°F) until they recrystalize. If they work, you may be able to sell them. You could run an ad in our MicroAds (classifieds), or track down your local solar energy society and pawn them off on some nerd there. I might even be interested. At about 30 pounds each, the shipping will be a bit pricey.

I cannot find any info on the manufacturer, or original cost. So your guess on their value is as good as mine. I hope this helps. At least you know they are not radioactive. Ben Root ben.root@homepower.com

Windmill, One; Don Quixote, Zero
Dear Richard, When I put up my windmill, I cut as few trees as possible. I cannot get heavy equipment into the area where the windmill is, and the area is very wet and soft in the spring.

Last summer, the windmill did not seem to be putting out as much as I thought it should, so I dropped the tower and took the windmill to World Power. They tested it and said that it was OK electrically, but the bearings were close to failing. They removed the two old bearings and installed three new ones. They said to bring in the control box to be tested.

That night I went home and put the windmill back on the tower and raised the tower to about 45 degrees. The windmill was about even with the top of the trees. There was little or no wind. When I took the tower down, the upper two guy wires on the north side had gotten tangled in a black ash tree. I assumed that they would untangle themselves when the tower went back up. They didn't. I unfastened the upper two guys and was shaking them to untangle them, and the tower was shaking and swinging. It finally swung too much to the south and kept going.

Fortunately I was by myself and had no trouble making a speedy exit. As the tower was coming down, some of the guys tangled in a couple of trees on the south side so that the windmill got hung up about 7 feet above the ground. This was probably a best case scenario, since neither me nor the windmill suffered any real damage.

The tower is made out of four, 21 foot sticks of 3 inch schedule 40 pipe, threaded and coupled. I expected the pipe to snap at the threads, but got a long smooth bend instead. The real trick was to get the windmill off and get the tower on the ground. The second stick from the ground was bent and I pulled the wires out of the tower and cut the pipe off with a cut-off saw. The threads on the lower end of the third stick were distorted enough that I had to cut them off and align and weld a coupling on to reassemble the tower.

The tower is finally in one piece again and the lifting guys attached and adjusted. I also put a Davis weather station about 70 feet up. The final hold-up is getting a cable long enough to connect the weather station to the power shack. I should have the windmill up and operating before long.

The real output problem turned out to be a bad control box, which World Power replaced. The replacement pipe cost about US$100. There were also other incidentals. I have cut more trees, but should probably cut more yet. The repair cost was relatively low, though a lot of time was required.

The moral of the story is that there are some real dangers to working with a tower, and don't be a "tree hugger" when putting up a tower. You are welcome to publish any portion of this as long as you delete my name and address. This may be a valuable warning. Thank you. [Name Withheld, Somewhere in the Northern Hemisphere]

Thanks for sharing your experience. Wind energy is certainly the most hazardous of the RE technologies. I'd say you came out of your situation fairly gracefully, considering the possibilities. Gravity is great stuff, but when you start playing with towers and wind generators, it can be a force to be reckoned with. I hope other readers will take your warning, and get some experience with towers before they get into trouble. Ian Woofenden ian.woofenden@homepower.com

DHW Sizing
Hi, Just wanted to send a note about your series on solar hot water heating. Quite comprehensive and, as always with *HP,* lots of good nuts and bolts info. I would like to note one thing on sizing of storage for solar DHW. Here in Maine, after installing more than a hundred drainback systems, I think the ratio of 0.75 gallons water storage per square foot of collector will lead to overheating of the storage in the summer. While this will offer lots of hot water, the owner will see evaporative losses in the storage tank, and have very inefficient operation.

We saw excellent performance with storage ratios of one to two gallons of water storage per square foot of collector. This relegates the solar input to a preheat mode in the winter (low sun, low BTUs in, and cold weather cooling the collector), but larger storage offers higher efficiency year-round. We usually saw a properly sized system (64 square feet of collector with 120 gallons of storage) yielding 100 percent DHW in the spring and summer in Maine for a family of 2 to 4. Keep up the good work, Tom Gocze, Maine

Tom, I have never installed solar or lived with it in Maine, so I respect your comments. Just a thought though—in similar situations, I have advised people to give the panels more tilt angle (standing them up higher). This will increase winter performance when it's needed most, and cut down on summer gain. Smitty, AAA Solar • smitty@aaasolar.com

I always recommend that sizing should be based on a local contractor's experience. However, I would strongly suggest using two 4 x 10s rather than two 4 x 8s with 120 gallons of storage. The ratio of 1.5 gallons to 1 sq. ft. of collector area is ideal. Two 4 x 10s cost the homeowner about US$200 more than two 4 x 8s. The increase in collector area over two 4 x 8s is 25 percent. Computer analysis and my experience have shown about a 15 percent increase in savings year-round. There is no more labor or material cost installing two 4 x 10s than two 4 x 8s, only the increased collector cost. Tom Lane, ECS Solar • tom@ecs-solar.com

New Tara Owner Responds
Dear Richard, I have been a solar enthusiast since my first science experiment in the eighth grade. I started the first chimney sweep company in middle Georgia (which required mandatory reading of the original *Mother Earth News*), had a subscription to *The Solar Collector* in the eighties, and now get my fix from *Home Power,* as a subscriber for many years. As my business evolved and changed, I have been blessed by being able to live out some of my dreams. One of these has been to build a house using tools powered by solar energy, and then to live in a solar powered home. Having said that, I would like to respond to the letter about our PV system by Mr. Kahmann in *HP86.*

The question was asked, "What would be the payback on a system like that—60 to 80 years?" In the article on my home by Tom Lane with Linda Tozer in *HP84,* it was stated that a net metering law was passed in Georgia in the spring of 2001. Knowing in advance that this was going to pass was one of the reasons the system was designed as large as it was.

The original article also mentioned that with the guidance of Ken Fonorow of the Florida Home Energy & Resources Organization, we went with six inches of Icynene in the walls and roof, LP appliances, geothermal heat pumps, and all fluorescent bulbs, among other things.

Our house is large, but it is efficient. We found this out when we experienced a severe lightning storm that knocked out 7 of the 8 inverters, all 8 charge controllers, all 36 batteries, and scores of panels. We were forced to depend on the local grid while undergoing repairs. During December (which was extremely cold), we moved into our new 10,000 square foot house. There were lots of doors left open because of the moving process, plus the fact I have five children, aged four to fourteen, who believe a door is made for opening and closing. Our electric bill for the month, without our solar-electric system operating, was US$170, which proves that houses can be built correctly and efficiently. Conservation is king!

I appreciate Mr. Prusinski's and Mr. Frazier's letters in *HP87.* The bottom line is, I did the PV system for the only reason—it's the right thing to do! The added benefit is this: people who said it couldn't be done have been proven wrong, and these are the very souls who are now seriously considering becoming converts. Perception is reality, and sometimes you have to see it to believe it.

The icing on the cake is seeing my kids tell their friends, "We live in a house powered by the sun," and having them tell me that they heard these same friends telling other kids about solar energy. How do you buy advertising like that?

You have a great magazine, and I'm a lifetime customer. If somebody like Mr. Kahmann doesn't like my personal "contribution to society" by using solar energy, and this is the price to pay for the education of the "greening of America," bring it on! I can only hope to do the movement justice. Respectfully, Steve Davison

Net Metering in Georgia
Hi Kenton, I saw your letter in *HP86* titled "My Top Secret Guerrilla Solar Story," as well as Joe Schwartz's response, and wanted to provide some information about net metering in Georgia. Georgia did pass a net metering law during 2001.

Under the measure, SB 93, customers who produce their own electricity using renewable energy sources will receive payment from Georgia Power for any excess electricity they generate (aka net metering). The text of the bill is at www.legis.state.ga.us/Legis/2001_02/versions/sb93_SB93_APmat_10.htm

For more information, you might want to contact Georgians for Clean Energy in Atlanta (www.cleanenergy.ws/index.html). Take care, Dan Lieberman Program Manager, Green Pricing Center for Resource Solutions, PO Box 29512 San Francisco, CA 94129 415-561-2100 • Fax: 415-561-2105 • dan@resource-solutions.org

Ozonal Notes

Sharks in the Power Supply

Richard Perez

Recent utility restructuring schemes assume that electricity can be treated as a commodity. While utility restructuring was supposed to lower the cost of electricity to consumers, just the opposite has happened—electricity has become more expensive.

While consumers pay more for electricity, the power brokers have been making record profits. The gyrations of the energy industry within the last year have clearly shown that treating electricity as a commodity, along with recent utility restructuring, is akin to putting the sharks in charge of the fish tank.

Is Electricity a Commodity?

My *Webster's Dictionary* defines a commodity as, "an article of trade or commerce, especially a product as distinguished from a service." Commodities are products such as wheat, gold, oil, soybeans, milk, and pork bellies. These commodities come from hundreds of thousands of sources, and are traded, both in the present and future, in commodities markets. A failed wheat crop can cause the price of wheat futures to rise, and will ultimately affect the price of a loaf of bread in grocery stores.

Utility-supplied electricity should not be a commodity, but a service. Commodities all have a storage life. Wheat can be stored for years, as can gold, oil, and soybeans. Some commodities, such as milk and pork bellies, are more perishable and have shorter storage lifetimes, on the order of weeks and months. Utility-supplied electricity, on the other hand, is very perishable and has a storage life of milliseconds—essentially it cannot be stored.

The ability to be stored is one distinguishing characteristic of all commodities, and is what enables them to be traded in real time and as futures in commodities markets. If the flow of pork bellies is interrupted for a few weeks, folks will have to forego bacon with their eggs. If the flow of electricity is interrupted for a few weeks, we have no alternative products, and a very serious situation develops.

While we won't starve if we have to do without bacon for a while, interruption of electricity, even for a few hours, is a big problem. The fact that electricity has no shelf life should take it out of the realm of commodities.

Commodities are all available from many, many sources. And these myriad sources are constantly changing. Anyone with a few thousand dollars can raise pigs and enter into the pork bellies commodity market. Anyone with land can raise wheat and become a wheat producer. Anyone with a working mining claim can become a gold producer.

The situation with utility-supplied electricity is far different. It takes many millions of dollars in capital to set up a utility-scale power plant or to put up an electrical transmission line. While someone can enter the pork, wheat, or gold markets in months, it takes many years to establish a new power plant or transmission network. There is an essential difference in scale and time between commodities and electricity. These differences make it impractical to treat electricity as a commodity.

Electricity Restructuring

"The business of America is business," said President Calvin Coolidge. Americans have a basic belief that organized society is best ordered and furthered by freedom, and this is mostly correct. But there are a few exceptions—areas where a market economy is unable to deliver the same performance that a more regulated economy can. Electricity is one. It is an essential public service that needs to be closely regulated to ensure high quality service at a reasonable price.

Electricity restructuring in America has been proposed and fostered by the utilities, not by the people. Utility and power broker claims of better service and lower prices in a less regulated environment have proven to be false. Their claim that electricity can be treated as a commodity is false. The history of this last year has shown this. Power prices in states with utility restructuring have dramatically risen—notably in California, Montana, and Nevada.

California's utility restructuring was largely formulated by Pacific Gas & Electric. They wrote the rules, and jammed them through the California legislature in less than three weeks. They got what they wanted, and now the state is mired in a massive, US$9 billion, economic disaster caused by electricity costs.

Not only has utility restructuring degraded the quality and increased the cost of electricity, it has also damaged the environment. Under restructuring, while the average consumer pays more, the big industrial consumers pay less. Utilities are falling all over themselves to cut electricity costs for large industrial customers.

One way to do this is to cut corners on environmental regulations. And the utilities have found government willing to aid them in their search for cheaper electricity by reducing environmental restrictions. Witness the recent federal denial of the Kyoto Protocol, and the feds' willingness to relax air pollution standards for the utility industry.

Energy Traders

Two of the biggest proponents of utility restructuring and treating electricity as a commodity have been Pacific Gas & Electric and Enron. Both companies saw huge profits to be made if electricity was treated as a commodity. PG&E was once the world's largest investor owned utility, but now it's bankrupt. Enron was the seventh largest corporation in America and the world's largest energy trader, but now it's bankrupt.

In 1999 and 2000, Enron spent US$5 million lobbying the federal government for restructuring. From 1993 to 2001, Enron spent US$5.3 million in donations to political campaigns. And Enron got exactly what it wanted—the ability to trade electricity nationwide as if it were a commodity.

At Enron's height in August of 2000, its shares were worth US$90.56 each. Just over a year later, on December 17, 2001, these same shares were worth US$0.25 each. With 743,905 shares outstanding, this amounts to a loss of over US$60 billion to Enron's shareholders. What happened with this experiment in a restructured economy for electricity? What happened to all this money?

Take the Money & Run

While both Enron and PG&E may be bankrupt, the companies that owned them and their subsidiaries are bloated with the money they have extracted from the public—profits from exorbitant electricity prices and profits from ripping off their shareholders. Take Enron for example.

Enron has 2,832 subsidiary companies. This is over one hundred times the number of subsidiaries of any other company in the energy industry. Furthermore, 874 of Enron's subsidiaries are in tax-free havens outside of the U.S., such as the Cayman Islands. These tax havens are in countries where bank accounts are not reported to governments and where the money is inaccessible to bankruptcy proceedings.

The roughly US$60 billion in Enron's shareholder equity was probably moved overseas into these hundreds of sheltered bank accounts. While Enron, the corporation, was bled dry, its upper level management gorged itself on its shareholder's equity. The sharks ate everything in the fish tank and then moved to warmer waters.

In the days prior to declaring bankruptcy, Enron upper level executives were madly selling off their Enron stock while at the same time prohibiting their rank and file employees from selling any of their stock. Just two days prior to declaring bankruptcy, upper level Enron executives granted themselves US$55 million in bonuses while at the same time laying off over 4,000 employees. A similar situation occurred in the days before PG&E declared bankruptcy—upper level management granted themselves over US$50 million in bonuses.

Both Enron and PG&E look like they were designed to go bankrupt. Were they sacrificial corporations designed to fail once they had bilked the people out of all the money they possibly could? The profits from these companies were transferred to other corporations where they could not be reclaimed by the public, shareholders, and creditors who were so blatantly robbed. Electricity industry restructuring, and treating electricity as a commodity, is a scam perpetrated by business sharks, and designed to make the rich richer and the poor poorer.

Sadly, thousands of people are being affected by Enron's bankruptcy. Many pension plans were heavily invested in Enron stock. Pensioners saw their retirement funds turn from comfortable to worthless in a matter of a few weeks. To appreciate the magnitude of Enron's rip-off, consider that electricity is about a US$220 billion a year industry in the U.S., and Enron was able to bleed off more than US$60 billion—over 25 percent of the annual gross of that industry.

Energy Futures

If utility-supplied electricity continues to be treated as a commodity, we will see more of this power shark activity. Prices will rise and reliability will fall. Big energy trading corporations will syphon off billions more into offshore accounts, and the U.S. will be bled white. We need to increase regulation in the electricity industry.

The irony of this entire situation is that energy doesn't need to be a commodity, or even a service that must be supplied by a utility. Both of these concepts are out of date—technology has provided us with other ways to make the energy we need.

Energy is a gift freely and democratically offered to us all each day by nature. As renewable energy users, we know this. Our energy comes from the sun, from blowing wind, and from falling water. We make our own electricity. Renewable energy is the ultimate shark repellent.

Access

Richard Perez, *Home Power,* PO Box 520, Ashland, OR 97520 • 530-475-3179 • Fax: 530-475-0836
richard.perez@homepower.com
www.homepower.com

Q&A

Send your questions to letters@homepower.com

Guerrilla Solar Inverters

Thanks very much for a great and informative magazine. I have a question on the solar guerrilla issue. The articles I have read both mention using the OK4U inverter, capable of interfacing with the grid. They state that this inverter is designed and certified for this purpose. What about other sine wave inverters? Are they acceptable for interfacing with the grid? What other types of inverters are "certified" for this purpose?

I have a Statpower sine wave inverter, model 1800/12. Will this inverter work with the grid as the OK4U does? Thanks, Skip Ambrose • skipchris@earthlink.net

Hey Skip, Only inverters designed to synchronize their AC output with the frequency of utility grid are capable *of feeding RE generated electricity onto the grid. The Statpower sine wave inverter, model 1800/12 does not have this capability.*

In addition to the OK4U/Trace MicroSine inverter, these inverters are designed for utility interactive applications here in the U.S.: AEI's GC-1000 and MM series inverters, www.advancedenergy.com; Trace ST and SW series inverters, www.traceengineering.com; SMA's 2,500 watt Sunny Boy inverters, www.sma-america.com. I hope this helps, Joe Schwartz joe.schwartz@homepower.com

State of Charge Question

I have a homemade system. Almost 200 watts of PV charging three gel cells and two marine batteries. My RV-2000 reports that the batteries start losing voltage around 3 PM, even *with* the sun shining. I know my five batteries lose at least 0.5 volts just in the afternoon. It's no wonder they are less than 13 volts at night. What is normal standby loss in a battery bank? What is the best way to know the health of the individual batteries, since they are connected in parallel? This is unlike an automobile battery, which can be evaluated by whether or not it will start the engine. A hydrometer or a load test? A load tester isn't cheap. Any recommendations? Lee K.

Hi Lee, Voltage is not a good indication of state of charge. It is merely the "electrical pressure" in the system, and depends not only on state of charge, but on the charge or discharge rate. You can pull the voltage down dramatically by putting a large load on the battery, and raise it dramatically by connecting a large charging source.

A fully charged 12 V lead-acid battery at rest (no charge or discharge, and surface charge removed by using a load for a while) will be at roughly 12.6 volts. With PV as your only charging source, I would never expect your battery voltage to be over 13 volts at night. Voltage might go as high as 15 during the day with full batteries and heavy charge.

If you suspect that an individual battery in your bank is in trouble, start by disconnecting it from the others and checking individual battery voltage with no charge coming into the battery. But your description does not immediately suggest to me that you necessarily have a problem. It's normal for voltage to run from 12.2 or lower to 15 or higher during the course of 24 hours under heavy discharge and charge.

You're not "losing" anything just because the voltage drops as the sun intensity lessens or your loads increase. It's like in a water system—when you open the spigot for a minute, the pressure drops a bit in the line, and when you turn on the pump for a minute, the pressure rises. But you haven't significantly changed the volume of water in your tank. Get a good amp-hour meter, get it calibrated properly, and use that as your primary indication of state of charge. Ian Woofenden ian.woofenden@homepower.com

Hi Lee, You do have a basic design problem with your battery pack. Flooded lead-acid batteries should be charged to 15 VDC. But gel-cell batteries are typically damaged if they are charged above 14.2 VDC. So in your case, the flooded marine batteries are most likely never being fully charged. Mixing different battery types in the same system is not a good idea. Joe Schwartz joe.schwartz@homepower.com

Would a Power Conditioner Help?

Hello Richard, We live off the grid and have used photovoltaics for more than ten years now. My wife recently bought a gas clothes dryer, a Sears Kenmore Elite. It's a bit of an energy hog (compared to the Staber washer). I wouldn't run it off our small battery bank alone (four L-16s), but with even partial sun, our system (600 watts of panels) can handle it no problem. The "electronic ignition" is a bit of a disappointment. It's not a piezo type spark, but a red hot glowing resistor. But it's only on for 5 to 10 seconds when lighting, and our modified square wave Trace 2524 handles that part fine.

The problem is that something on the circuit board doesn't seem to get along with the inverter. The board is heating up, smelling hot, and scorched on one corner. I have ordered another board and a manual from Sears, but before I install it, I thought I'd ask around for advice. Have you heard of any problems with this type of appliance? I saw the power conditioner discussed in *HP81.* Do you think that is a called for here? Any advice or referrals would be appreciated. Thanks, Seth Jacobs, Argyle, New York

Hello Seth. Some component, most probably a thyristor used for power control, is not compatible with modified square wave electricity. I suspect that the new board will fry just as the old one did.

A power conditioner may smooth out the modified square wave to the point where the dryer will gracefully accept the power, and it may not. The downsides to power conditioning are cost (about a buck a watt for the conditioner) and inefficiency (you will take about a 25 percent loss in energy through the power conditioner).

The best solution is to use a sine wave inverter. I know that this means replacing an expensive system component, but it's really the best and most cost effective solution. And all of your appliances will perform better, last longer, and be more efficient. Richard Perez richard.perez@homepower.com

Charge Components

Dear *Home Power,* My question relates to doubling up on charge components. I keep seeing installations that use Trace C40 or C60 charge controllers alongside Trace SW4024 or SW5548 inverters. Why the added cost of stand-alone charge controllers, when the inverters have the units built in?

Are the installers concerned with heat, or the cost of replacement due to failure? My reasoning would be, if the C40 charge controller failed, the inverter would keep the system running until it was replaced. If the internal charge controller failed, the system would be useless while the inverter is being repaired. Am I on the right track? Sincerely, R.S. Luce • Ronald_Luce@voltek.com

Hi Ron, The inverters do not have charge controllers built in. This is a fairly common misconception. The inverters have AC-powered chargers built in that can use generator or grid power to charge the batteries. But they have no capacity to control input from a PV array (except using the relays for slam-bang dumping, which is pretty rough). So, you still need a charge controller to keep the batteries from being overcharged. Ian Woofenden ian.woofenden@homepower.com

Concrete Block Insulation Project

My home is a 26 by 54 foot concrete block structure with a concrete floor in northwest Arkansas. The blocks are filled with granular insulation and a 3/8 inch foam insulation on the exterior surface. This house is very hard to heat in the winter, and after sealing all possible air leaks, I am sure I have conductive loss through the walls and floor. I have considered adding more insulation to the outside in hopes of using the mass of the walls to maintain inside temperature. Could you advise me or guide to a source of help in this area before I commit to the project? Thanks in advance for any advice. Sincerely, Bobby White

Hello Bobby, You're correct that heat loss through the blocks is the problem. Insulating the outside of the walls is your best bet. Two inch closed-cell rigid foam insulation has an R-value of about 14. Tape the joints and fill any gaps with expanding foam insulation. This will create a continuous insulative layer. You'll also need some sort of siding to cover the insulation that's above grade. For a comprehensive look at insulation types and applications, check out the Insulation Handbook *by Robert Bynum, reviewed by Pete Gruendeman on page 104 of this issue. Joe Schwartz • joe.schwartz@homepower.com*

Inverter Sizing

Hi, Thanks for a great magazine. I read it cover to cover every time it arrives. We have been off the grid for a little over two years now, and we are considering replacing our 1,500 watt modified square wave inverter with a sine wave model. Our present inverter is rated for 1,500 watts, but 99 percent of the time, we use less that 600 watts. I understand that an inverter will be more efficient when it is operated nearer its design rating. Would we better off with a smaller inverter?

My second question has to do with our laptop computer. It will not charge on the modified square wave inverter. The charge indicator will show that the battery is fully charged, but the computer will die after 5 minutes on battery power. If I charge it using the grid, it holds a charge for an hour or so. Has anyone else had this problem? Thanks, Dan Bisbee, St. Johnsbury, Vermont

Hello Dan, Most inverters are more efficient when running at about 20 to 30 percent of their full rated output power. In your case, I'd recommend keeping your mod-square inverter and supplementing it with a smaller sine wave model such as the Exeltech XP-1100. This will give you a bigger inverter for large jobs, and a super-pure inverter for delicate electronics.

Many pieces of computer equipment have problems with mod-square waves, and your laptop is probably one of them. Richard Perez • richard.perez@homepower.com

Hi Dan. It could also be that your batteries have outlived their useful life. They do have a finite number of charge/discharge cycles. My laptop has the same problem as yours, even though most of the battery charging happened on sine wave power. In my case, I blame it on the computer's battery-charging algorithms. I regularly made sure that my batteries were fully discharged and then fully recharged. So they should not have had that infamous "memory effect" that results in decreased battery capacity for NiCd and some other rechargeable batteries. Yet my batteries got about a quarter of the life I expected from them. Your mileage will vary. Michael Welch • michael.welch@homepower.com

Get A Job!

Home Power **is proud to offer a new feature on our Web site called "Get a Job!"**

Home Power **encourages businesses to post their renewable energy related jobs on our Web site at no charge.**

If you want to work in the RE industry, you can search the listings for your dream job.

Make your work part of the solution!

www.homepower.com

**WWW.
HOMEPOWER.
COM**

Adopt a Library!

When Karen and I were living with kerosene lamps, we went to our local public library to find out if there was a better way to light up our nights. We found nothing about small scale renewable energy.

One of the first things we did when we started publishing this magazine many years ago was to give a subscription to our local public library.

You may want to do the same for your local public library. We'll split the cost (50/50) of the sub with you if you do. You pay $11.25 and Home Power *will pay the rest. If your public library is outside of the USA, then we'll split the sub for your location, so call for rates.*

Please check with your public library before sending them a sub. Some rural libraries may not have space, so check with your librarian before adopting your local public library. Sorry, but libraries which restrict access are not eligible for this Adopt a Library deal—the library must give free public access. — Richard Perez

To Adopt a Library write or call

Home Power®
PO Box 520, Ashland, OR 97520 USA
1-800-707-6585 or 541-512-0201 or FAX 541-512-0343
hp@homepower.com • www.homepower.com

Home Power MicroAds

Rates: 15¢ per CHARACTER, include spaces & punctuation. $20.00 minimum per insertion. All MicroAds are published in both the print and web versions. Please send check or Visa/MC data with ad. Please, no money orders. We do not bill MicroAds, they must be paid for in advance of publication. Your cancelled check or credit card bill is your receipt.

Help us prevent fraud! Home Power MicroAds from individuals must supply serial number(s) for equipment being sold. Businesses must supply published phone number(s) and physical address. While Home Power is doing everything we can to prevent fraud, we can assume no responsibility for items being sold.

Nickel-Iron batteries. Original, old, Edison cells, totalling approximately 800 amp hours at 12 V. Refurbished 5 years ago, not used since. $500 OBO, you pick up from storage in Arcata, CA. 707-822-7884 info@redwoodalliance.org

---

VERY LOW PRICES Solar Electric & Thermal Equip. Panels-Inverters, Charge regulators, wind generators-pumps-controls Please Call (888) 817-1737 or write to 6 Cresta Cir. #8, San Rafael, CA 94903 www.afterhourssolar.com

---

MAKE YOUR OWN FUEL. Bio-Diesel supply list. Hard to find components, at good prices. Send SASE to M.Y.O. Fuel, PO Box 194 Stony Brook NY 11790

*** HEY GUERRILLAS! *** We have OK4U grid-tie, sine-wave inverters plus accessories! Easy four-wire hookup! Add two 12V PV panels and join the revolution! These are new units with full manufacturer's warranty. Data interface for remote monitoring and control is also available. (IBM-PC & Win95/98 reqd.) OK4U-100(100 Watt) US$240.00 OK4U-75(75 Watt) US$175.00 DC-1(Data interface) US$125.00 Summit Communications & Electronics Box 553, Willimantic, CT 06226 info@sumcom.net *** 860-456-3043 ***

WIND TURBINES! Best prices nationwide. Bergey- Aeromax-Turbex. www.pineridgeproducts.com 406-738-4284

HOW TO BUILD A SOLAR HOT WATER SYSTEM, Build your own collector, Book and Kit available at www.JC-SolarHomes.com

---

HYDROELECTRIC SYSTEMS: Pelton and Crossflow designs, either complete turbines or complete systems. Assistance in site evaluation and equipment selection. Sizes from 100 watts to 5 megawatts. Manufacturing home and commercial size turbines since 1976. Send for a free brochure. Canyon Industries Inc., P.O. Box 36 HP, Deming, WA 98244, 360-592-5552. e-mail: citurbine@aol.com web page: canyonindustriesinc.com

---

PROPERTY CARETAKERS/Housesitters enjoy rentfree living, worldwide 700+ opportunities available! The Caretakers Gazette (715) 426-5500. www.caretaker.org

---

AUTO STANDBY Generators Propane or Natural gas 6 KW – 40 KW Xfer switch incl. Tel: 732.271.7704 Fax: 732.271.9990 www.focallighting.com 1830 Washington Valley Rd. Martinsville, NJ 08836

ELECTRIC POWER YOUR BICYCLE. Regenerative Electric Auto. Homemade Hydrogen. Plans catalog $1. Criztoz,28 E Jackson #C1003 (AEHP), Chicago 60604

---

www.solarseller.com We carry an extensive line of IN-STOCK and READY-TO-SHIP alternative energy equipment and components. Credit cards, Paypal, checks or money orders accepted. John Drake Services, Inc., 1427 E.68 th.St.,Long Beach,CA 90805,(562)423-4879,fax 728-9941, email: john@solarseller.com

---

UNUSED SURPLUS INDUSTRIAL BATTERIES—Save 65-75%! If ever batteries could be called beautiful, these are they. Top of the line, sealed, valve regulated, no maintenance, V.R.L.A. technology. Never used or discharged. Super heavy duty steel cases, includes interconnect hardware, s.s. fasteners, and owners manual as shipped from factory. Several sizes from 615 A.H. to 1440 A.H. at 8-hour rate. 12-24 or 48V sets. Call for detailed specifications, photos, prices, and availability. Davis Power Systems Design Inc., 3807 West Sierra Hwy. #6, Acton CA 93510. (661) 269-5410.

EARTH SHELTERED HOMES This definitive manual by noted authority Loren Impson features detailed building instructions for the amazingly affordable and practical Ferro Cement Domes. Only $15 from Sun Life, 71 Holistic Mount Ida AR 71957 www.2BbyD.com

---

XXXXXXXXX USED SOLAR MODULES XXXXXXXXX XXXXXXXXXXXXX 64 Watts $319 XXXXXXXXXXXXX Used MSX60s $295, BZ 8 amp pwm controller $49, Ex 2KW inverter SB, 110 amp charger New $850, 3000+ watt resistors $35, new 75 Watt modules $375. Buy, sell New/Used, Trace, NiCds. refrigerator. Try to match anyone's prices. Call or send S.A.S.E. to Craig Eversole, 10192 Choiceana, Hesperia CA 92345 for free flyer. M/C VISA Discover 760-949-0505Used MSX60s $295, BZ 8 amp pwm controller $49, Ex 2KW inverter SB, 110 amp charger New $850, 3000+ watt resistors $35, new 75 Watt modules $375. Buy, sell New/Used, Trace, NiCds. refrigerator. Try to match anyone's prices. Call or send S.A.S.E. to Craig Eversole, 10192 Choiceana, Hesperia CA 92345 for free flyer. M/C VISA Discover 760-949-0505

SATELLITE TV - Large selection of items at reasonable prices. We specialize in Big Dish TVRO C & Ku Band equipment. Check us out at www.daveswebshop.com

---

YOUR DREAM HOME FOR SALE! BLUE MOUNTAINS-Eastern Oregon. Forested 80 Acres, solar powered. Self-contained. Year-round access. Newer house, huge shop, barn. Deer, elk, antelope, coyote, many birds. Thinned and Pruned 541-542-2323 Galen

---

Honda Generators - 1000 to 10,500 watts. Fast shipping and great prices! www.hayesequipment.com 1-800-375-7767

VERMONT PV DEALER. David Palumbo/Independent Power & Light has been designing and installing PV systems for more than 12 years. Trace and Exceltech inverters. Siemens, BP, Kyocera and Solarex PV's. Harris Hydro. Surrette, Rolls, and Dyno batteries. Honest dealer who offers personal support and service. "David is one of the original RE pioneers... he knows how to really squeeze all the energy out of a KWH!" Richard Perez (HP60). I P & L, 462 Solar Way Drive, Hyde Park, VT 05655. Phone 802-888-7194. Email: ipl@sover.net. Web site: www.independent-power.com. No catalog requests please. Please call for appointment before visiting.

WINCHARGER PARTS (brushes, blades, etc) new and used for 12, 32, and 110 volt models. (406) 547-2266 Montana, (716) 358-2534 New York

---

NO. CALIF–Solar powered home for sale 1000+SQ FT, on 40 acres, adjacent to nat'l forest. Basement/garage. Good well. Quiet. Beautiful views, Trees. $105,000 PH 530-459 1110 MSG. or sneetie58@aol.com

---

PLANS, KITS, BOOKS and supplies for alternative energy projects. Build your own solar cells, generators, vegetable oil heaters, and much more. See us on the web at: WWW.KENNEKE.COM Email: jon@kenneke.com

---

www.sunprosolar.com lots of renewable energy products, information, interactive bulletin boards+more

Index to Advertisers

AAA Solar Supply — 115
Abraham Solar Equipment — 123
ABS Alaskan — 107
Abundant Renewable Energy — 107
Adopt a Library — 140
Advanced Composting Systems — 105
Advanced Energy Group — 31
Advanced Energy Inc — 44
Alternative Energy Store — 95
Alternative Technology Assoc — 136
AstroPower — 19
Atlantic Solar — 68
B.Z. Products — 103
BackHome — 96
Backwoods Solar Electric Systems — 69
Bailey's Inc — 124
Bay Solar Power Design — 102
Bergey Windpower — 21
Biolet — 52
Bogart Engineering — 103
BP Solar — 2
Brand Electronics — 111
C. Crane Company — 136
CheapestSolar.com — 96, 103, 105
Communities magazine — 136
Controlled Energy Corporation — 101
Dankoff Solar Products — 67, 73
Davidge Controls — 107
Direct Power and Water Corp — 60
Dynamx — 125
Earth Solar — 97
Electro Automotive — 137, 141
Electron Connection — 61
EmpowerCo — 91
Energy Conservation Services — 45
Energy Designs — 111
Energy Outfitters — 32, 43
Energy Systems & Design — 102
ETA Engineering — 111
EV Solar Products — 91
Exeltech — 42
Get a Job! — 140
GotSolar.com — 86
Great Northern Solar — 140
Guerrilla Solar T-shirts — 86
H-Ion Solar — 141
Harris Hydroelectric — 90
Heliodyne — 115
Hitney Solar Products — 124
Home Power Back Issues — 125
Home Power Biz Page — 81
Home Power CD-ROMs — 80
Home Power Sub Form — 81
Horizon Industries — 102
Hydro Coil — 103
Hydrocap — 105
Hydrogen Appliances — 102
Independent Designs & Creations — 67
Innovative Energy Systems Inc — 97
Inverter Repair — 123
Jack Rabbit Energy Systems — 72
KTA Services Inc — 123
Kyocera Solar Inc — OBC
Matrix — 90
Maui Solar Energy Software Corp— 87
Meridian Energy Systems — 101
Midwest RE Fair — 33
Monolithic Domes — 96
Morningstar — 87
MREA Workshops — 79
Natural Light Tubular Skylights— 107
NeatSolarStuff.com — 111
New England Solar Electric Inc — 137
Newinli International Inc — 78
Norris Screen & Manufacturing — 107
Northern Arizona Wind & Sun — 73, 91
Northwest Energy Storage — 72
Norwood Industries — 137
Obadiah's WoodStoves & Alternative Energy — 102
Offline — 141
Outback Power Systems — 68
Planetary Systems Inc — 78
Pony Enterprises — 141
PowerPod Corporation — 125
Quick Start Reading Special — 136
Rae Storage Battery Company — 111
Ram Company — 111
Renewable Energy Videos — 96
RightHand Engineering — 110
Rolls Battery Engineering — 53
RV Power Products — 20
San Juan College — 102
Schott Applied Power Corporation — IBC
Simmons — 115
SMA America Inc — 4
SolAqua Inc — 91
Solar Depot — IFC
Solar Electric Inc — 53
Solar Energy International — 77
Solar Interior Design — 105
Solar Pathfinder — 119
Solar Village — 91
Solar Wind Works — 140
SolarFest RE Fair — 78
SolarHost.com — 77
SolarSense.com — 9
SolEnergy — 96
Solwest Energy Fair — 86
Southwest Solar — 122
Southwest Windpower — 18
Stonepath Power Systems — 107
Sun Electronics — 85
Sun Frost — 87
Sun Spot Solar & Heating — 97
SunEarth Inc — 87
Sunelco — 44
Sunweaver — 42
SunWize — 79
Surrette Battery Company Ltd — 69
Tour de Sol — 137
Trojan — 45
U.S. Battery — 5
UniRac — 110
Veggie Van — 119
Wattsun (Array Tech Inc) — 105
Windstream Power Systems — 103
Xantrex — 1
Zane International — 105
Zephyr Industries Inc — 133
Zomeworks — 79


25 YEAR WARRANTY
KYOCERA
PRODUCT SHOWCASE
KC70
KC60
KC45
KC50
KC40
KC35
Kyocera's advanced cell processing technology and automated production facilities have produced a highly efficient multicrystal photovoltaic module.
The conversion efficiency of the Kyocera solar cell is 14%.
These cells are encapsulated between a tempered glass cover and an EVA pottant with PVF back sheet to provide maximum protection from the severest environmental conditions.
The entire laminate is installed in an anodized aluminum frame to provide structural strength and ease of installation.

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #88

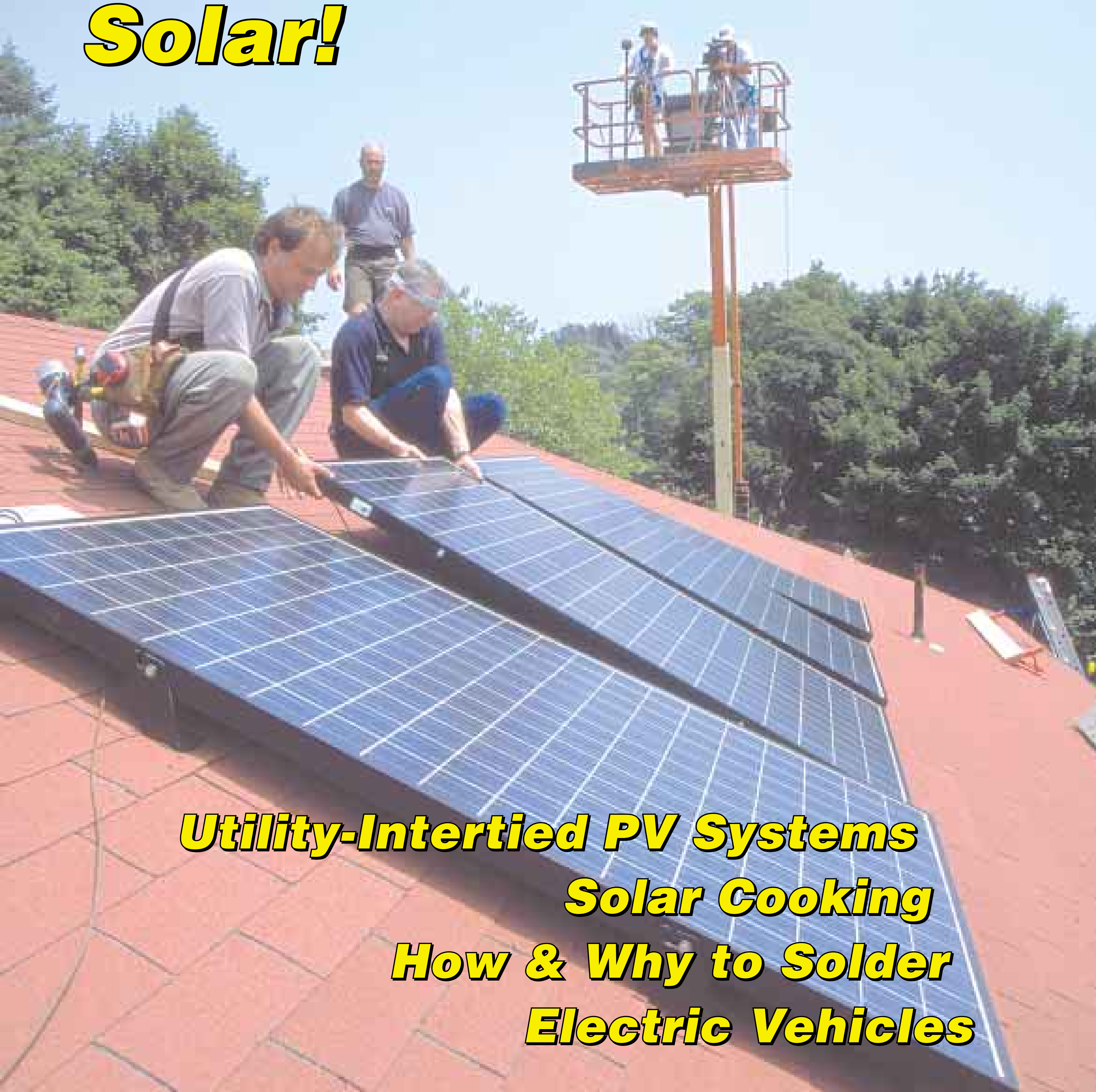
April / May 2002

$6.95 U.S.

$10.95 CAN.

Display until June 1

Lights, Camera, Solar!



Utility-Intertied PV Systems

Solar Cooking

How & Why to Solder

Electric Vehicles

Home Power Subscription

$22.50 per year (6 issues) to U.S. Zip Codes via 2nd Class U.S. Mail
$43.00 per year (6 issues) to U.S. Zip Codes via 1st Class U.S. Mail
$30.00 (US$ drawn on U.S. Bank) International Surface Mail, see pg. 81 for Air Rates

Home Power magazine, PO Box 520, Ashland, OR 97520
Subscribe online at: www.homepower.com
Subscriptions: 800-707-6585 (inside USA) or 541-512-0201 or Fax 541-512-0343

To subscribe, please fill out the sub form below, enclose payment as a check, money order, or Visa/MasterCard information, and mail this form. Tape the form well or use an envelope so your check won't fall out. Please allow up to ten weeks for the start of your 2nd class sub. For **International Subscriptions or Back Issues of *Home Power,* please see page 81.**

❑ New 2nd Class Sub-$22.50 to USA Zip Codes
❑ New 1st Class Sub-$43 to USA Zip Codes
❑ Sub Renewal Specify 1st or 2nd Class
❑ Change of Address (include old address)
❑ Gift Subscription From (your name and address here) ____________________

DO YOU WANT US TO SEND YOU A SUBSCRIPTION RENEWAL NOTICE?

The number of the last issue in your subscription is printed on your mailing label.

❑ Yes, remind me by mail when my subscription runs out. ❑ No, I'll check my mailing label so we can save energy & paper.

PLEASE CLEARLY PRINT THE COMPLETE NAME AND ADDRESS FOR THIS SUBSCRIPTION:

NAME ____________________

STREET ____________________

CITY ____________________ STATE __________ ZIP __________

PHONE ____________________ EMAIL ____________________

❑ VISA ❑ MasterCard **Credit Card Orders:** please check the type of card you have and fill in the information below.

Signature (as shown on card) ____________________ Exp. Date __________

Credit Card Number ____________________ Amount $ __________

The following information about your renewable energy usage helps us produce a magazine to better serve your interests. This information will be held confidential. We do not sell our mailing list. Completion of the rest of this form is not necessary to receive a subscription, but we would greatly appreciate your input.

NOW: I use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ❑ Solar power
- ❑ Wind power
- ❑ Hydro power
- ❑ Biomass
- ❑ Geothermal power
- ❑ Tidal power
- ❑ Other renewable energy resource (explain)

The GRID: (check all that apply)

❑ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

❑ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

FOLD HERE AND TAPE EDGES

Please write to us here. Tell us what you like and don't like about Home Power. *Tell us what you would like to read about in future issues. Thanks for your attention and support.*
Check here ❑ *if it is OK to print your comments as a letter to* Home Power.

FOLD HERE AND TAPE EDGES

Return Address

PLACE
FIRST
CLASS
POSTAGE
HERE

Home Power magazine
Post Office Box 520
Ashland, OR 97520

HP#88